PB84-156439

Costs and Air Quality Effects of Selected Alternatives to Annual Open Field Burning in Northern Idaho

Engineering-Science, Inc., Boise, ID

Prepared for

Environmental Protection Agency, Seattle, WA

Jun 83

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. EPA 910/9-83-113

2.

3. Recipient's Accession No. PB8 4 156439

4. Title and Subtitle
Costs and Air Quality Effects of Selected Alternatives to Annual Open Field Burning in Northern Idaho

5. Report Date
June, 1983

6.

7. Author(s)
Scott A. Freeburn

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Engineering-Science, Inc.
760 Warm Springs Avenue
Boise, Idaho 83702

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency - Region 10
1200 Sixth Ave.
Seattle, WA 98101

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This report focuses on methods to reduce emissions from agricultural field burning through alternative post-harvest treatments involving reduced burning.

Annual field burning is conducted by producers of Kentucky blue-grass seed, and some cereal crops in northern Idaho.

From the analysis of the effects of reduced-burning alternatives, the major findings were: 1) Air contaminent emissions and net returns to growers would be reduced in proportion to reductions in burning. The reduction in returns to producers would be due to increased production costs, more frequently incurred establishment costs, and reduced seed yields. 2) Increases in crop prices are not likely to be sufficient to offset the increased costs to farmers in the near term. 3) Though maximizing residue removal generally is best for yield retention and stand maintenance, non of the three residue treatments (straw removal, straw and stubble removal, no residue removal) was clearly superior based upon an emission benefit-to-cost analysis.

The report recommends steps for the most effective approach to making emission reductions.

17. Document Analysis a. Descriptors

Agricultural economics
Smoke management
Air quality management
Field Burning

b. Identifiers/Open-Ended Terms

Idaho

c. COSATI Field/Group

18. Availability Statement: unlimited

19. Security Class (This Report) unclassified

20. Security Class (This Page) unclassified

21. No. of Pages 245

22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

EPA-910/9-83-113

PB84-156439

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Prepared for
U.S. Environmental Protection Agency
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1200 Sixth Avenue
Seattle, Washington 98101

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NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

COST AND AIR QUALITY EFFECTS OF SELECTED ALTERNATIVES TO ANNUAL OPEN FIELD BURNING IN NORTHERN IDAHO

PREPARED FOR:

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MAY, 1983

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SECTION 1

REPORT SUMMARIES

1. REPORT SUMMARIES

1.1 Brief Summary

Agricultural field burning is conducted in northern Idaho Kentucky bluegrass seed fields to control diseases, weeds, and insects and related pests. The practice also economically eliminates straw residues and stimulates greater seed yields. Cereal crop residues also are burned in some areas of northern Idaho to substantially reduce residue loads, thereby reducing the costs of incorporating this material into the soil and allowing complete decomposition of remaining residue and root materials.

The burning of these residues also results in the emission of large quantities of air contaminants, mostly fine particulate matter, carbon dioxide, carbon monoxide, and hydrocarbon gases. The effects of these emissions on visibility, particulate loading, and odors are dramatic. In addition, the air quality effects of field burning smoke have been associated with adverse respiratory health effects in some individuals. The control of these air quality effects is normally approached through two means: reductions in the actual emissions from burning; and

reductions in the level of exposure of people to smoke through appropriate scheduling of burning (smoke management). Since emission reductions and operational smoke management can only be accomplished imperfectly both approaches should be considered to effect the greatest feasible reduction in smoke impacts. This report focuses on methods to reduce emissions through alternative post-harvest treatments involving reduced burning. The results of this analysis and proposals based on it should be considered in light of present and projected smoke management capabilities and the goals established through the public regulatory processes for control of field burning smoke impacts.

From this analysis of the effects of reduced - burning alternatives, key findings may be stated:

1. Air contaminant emissions and net returns to seed producers would be reduced in proportion to reductions in burning. The reduction in returns to producers would be due to increased production costs, more frequently incurred establishment costs, and reduced seed yields;
2. A reduction in burning would result in increased costs and reduced net returns for

cereal growers in irrigated and gravelly soils where burning has been used to reduce straw loading and related straw incorporation costs;

3. Increases in crop prices are not likely to be sufficient to offset the increased costs to farmers in the near term;
4. On the basis of minimum costs per unit of emission reduction, the various post-harvest treatment alternative analyzed here are rated as follows:

    a. Elimination of burning of cereal stubble in dryland areas;
    b. Elimination of cereal stubble burning in all other areas; and
    c. Elimination of all cereal field burning and reduction or elimination of grass seed residue burning.

5. Data is so limited regarding the response to reduced burning of the 32 varieties of Kentucky bluegrass certifiable in Idaho that a distinction between varieties on this basis cannot be made. Of the varieties for which data is available, only "Merion" clearly is less affected by reduced burning;

6. Though maximizing residue removal generally is best for yield retention and stand maintenance, none of the three residue treatments (straw removal, straw and stubble removal, no residue removal) was clearly superior based upon an emission benefit-to-cost analysis;

7. With the understanding that:

    a. The understanding the control of air pollution from field burning would result in increased expenses;
    b. As with other sources of air pollution, these costs would be borne primarily by the source operators (the seed producers); and
    c. To noticeably lessen the present impact of field burning on air quality in sensitive areas of northern Idaho, emissions likely would need to be significantly reduced, the following steps are recommended as the most effective approach to making such general emission reductions:

        1) Eliminate the burning of all cereal grain;

2) If implementation of step (1) and any associated smoke management restrictions have not adequately reduced smoke effects, also restrict the burning of Kentucky bluegrass fields to no more than two years out of three; and
3) Consider further reductions in burning after a detailed economic analysis of the effects of steps (1) and (2).

Though such emission reduction could be implemented through additional operational smoke management restrictions, such an approach could not differentiate as to the need to burn a given crop.

Long-term additional annual costs of these steps would vary from approximately $34 dollars per acre for step (1) to approximately $60 per acre for step (2) based on present seed prices. Additional costs would vary depending on farm circumstances, but would increace with reduced burning reaching approximately $200 per acre in the absence of burning;

8. Reductions in burning would likely cause a shift in Kentucky bluegrass acreage to areas of lower production costs, that is, areas where annual open burning is allowed. Reductions in burning beyond the two years out of three option would be expected to cause a very rapid acreage movement to other suitable growing areas where burning remains relatively unrestricted. At present, these areas would be in eastern Washington and various locations in Oregon; and

9. Methods for partially reducing burning of any crop would require careful tracking of burning activities by a regulatory agency to insure (a) compliance with any necessary regulations and smoke management procedures and (b) that there was an equitable reduction in burning.

1.2 Extended Summary

Kentucky bluegrass (Poa pratensis L.) is the principle grass seed crop grown in northern Idaho. The seed from this perennial grass is used for both forage (pastures) and turf. Some thirty-two varieties of the species are eligible to be certified in the state as meeting requirements for genetic trueness, seed purity and quality, and minimum gemination levels. Such certified seed from Idaho is marketed throughout the United States and foreign countries at prices established by U. S. and world supply of and demand for the seed.

Most of the U. S.'s (and world's) production of Kentucky bluegrass seed is from the Pacific Northwest states of Idaho, Oregon, and Washington with each state producing almost one-third of the U. S. supply. The Inland production region of eastern Washington and northern Idaho is in competition with and influenced by seed production in Oregon and vice versa. Thus, changes in production levels due to weather or other factors in one region influence price and production in the other. Due to this competitive market situation, increased costs of production in one area will not necessarily result in a proportional increase in seed price, especially in the short-term.

Field burning has been used as a routine cultural practice for grass seed cultivation in the Pacific Northwest since the late 1940's when it was found to be an effective control of some troublesome grass diseases. With annual use, it also was found to control many undesirable weeds and most stem and leaf dwelling insects. It was established that the seed yields of most species grown in the area were substantially increased when burning was conducted annually, compared to when burning was not used. Pacific Northwest climatology and cultural practices have resulted in seed yields and quality that have allowed the industry to compete very effectively against other seed-producing areas. Burning is considered by agricultural experts as perhaps the most important cultural practice.

As reduced burning is contemplated to reduce air pollution, the effectiveness of alternative means to control weed, disease, and pest problems must be considered as well as the effect of reduced yield. Studies of all these effects have been conducted, and though data is not as complete as desired, the role of field burning in each of these areas have been reasonably well defined.

Without burning, Kentucky bluegrass yields decline with increasing age of the crop stand until a stable yield equal to about 40% of the young stand yield is obtained. Routine burning maintains yields near those of a young stand. Yield reduction, rate of reduction, and responsiveness to fire are all variety dependent. The effect of burning on yield can be partially reproduced by mechanical removal of straw and stubble. The effectiveness of such mechanical straw and stubble removal in maintaining seed yields declines with increasing stand age.

Diseases and insects which attack the stems, leaves, and seed head of the grass plant are effectively controlled by burning. Disease innoculum, growth media, insects, and insect eggs are all eliminated through burning. Root- and crown-feeding pests are not effectively controlled by burning and must be treated chemically. Fire, through the resulting elimination of straw and stubble residue, is instrumental in assuring contact between chemicals and such underground feeders.

Weed seed and any lost crop seed is incenerated or killed by burning, thus eliminating potential plant competition to the perennial crop. Elimination of weeds also can be critical to maintaining seed purity standards.

A reduction in burning from the present levels may result in any combination of the following: 1) Decreased yields; 2) Increased incidence of weeds; 3) Increased incidence of diseases; and 4) Increased incidence of insect and related pests. To partially offset these adverse effects of reduced burning, seed producers can implement a variety of other treatments including: 1) Mechanical straw and stubble removal; 2) Increased use of chemical pesticides; 3) More frequent crop rotations; 4) Increased seed cleaning; and 5) Flaming or machine burning (normally after straw removal). In the case of cereal crops burned to reduce the overall residue loading, not burning would require increased straw chopping and tilling activities to prepare a satisfactory seed bed immediately following harvest. Each of these post-harvest operations increases production costs.

In analyzing methods to effectively reduce emissions, a number of post-harvest treatment alternatives were reviewed. The additional costs of these treatments compared to open burning were assessed, based on available economic data and research of the effects of non-burning alternatives on yield. Reductions in emissions were assumed to be proportional to acreage not burned with either factor acting as a surrogate for improved air quality, assuming some baseline conditions. Thus, benefits (improved air quality) and costs could be assessed based upon a weighted analysis of post-harvest treatment alternatives. Also, estimates on the required increase in crop prices to maintain assumed profit levels or net returns could be determined.

Benefit-to-cost relationships were determined for three Kentucky bluegrass varieties on representative soils for a variety of post-harvest treatments including: no burning, burning on alternate years, and burning two of three years. In non-burn years, straw, straw and stubble, and no removal were considered. Benefit-to-cost relationships were also determined for winter wheat on average and gravelly soils.

Based on these determinations, the most cost effective reduction in emission would be derived through eliminating the burning of cereal residues.

Additional costs associated with this practice would range from $1 to $35 per acre with the highest cost for the gravelly soils typical of the Rathdrum Prairie.

Additional production operations and costs to offset the effects of reduced burning were much more substantial for grass seed fields. Increased production costs ranged from $16 to $130 per acre. Average yield reductions varied between 5% and 52%, depending upon variety, treatment, and assumed crop stand life. Consequently, benefit-to-cost ratios are much lower for grass seed crops than the winter wheat analyzed. Of the alternative grass seed treatments reviewed, burning two of three years resulted in a high benefit-to-cost ratio and the smallest increases in additional costs.

Based on this analysis, a procedure is provided that would prohibit burning of cereal crops. If additional emission reductions are necessary, the procedure would support burning of grass seed crops two out of three years. To achieve this, a reduced priority for burning would be given to fields that had received annual burning for the previous two years and to young stands.

During the initial years of such a program, burnable acreage of any ownership would be limited to existing grass seed acreage. Any subsequent reductions in grass seed residue burning would be effected by limiting burning to two-thirds of the existing grass seed acreage.

The procedure would maximize, to the extent possible, farm management decisions regarding burning by establishing an upper limit only on acreage to be burned by a given ownership. The upper limit, based on the fields registered for burning, would not restrict the burning of any individual field. To avoid over-registration aimed at garnering additional acreage for burning, registered acreage would need to be checked against historical acreage amounts for each ownership.

It is noted that such a procedure would require extensive collection and year-to-year tracking of data on individual fields. The data could be collected in conjunction with the registration for the smoke management program under which the fields would be burned.

SECTION 2

INTRODUCTION

2. INTRODUCTION

Some 21,000 acres of perennial grass seed crops are grown in Northern Idaho. Virtually all of the acreage is dedicated to Kentucky bluegrass (*Poa pratensis* L.) varieties with very minor acreages of other perennial grasses. For reasons to be discussed in this report, the grass seed fields are burned each year after harvest. This activity results in large quantities of air contaminants being released to the atmosphere causing pronounced increases in particulate loadings, reductions in visibility, and adverse effects on the health of individuals. In addition, because of the adverse effect on aesthetic air quality values, it has been proposed that the burning of fields has resulted in a reduced tourist trade in this area. (Porter, 1982)

In addition to grass seed crops, some 5000-7000 acres of cereal crops are burned each year in the same area. Though the character of the smoke is somewhat different from that produced by grass seed residues, the net effect is a further degradation of air quality and a possible lengthening of the burning season.

2.1 Purpose and Scope of Report

Idaho air pollution regulations allow agricultural open burning to be conducted provided no alternative non-burning method "producing a similar public benefit" is available. (Idaho Board of Health and Welfare, 1979) The rules further require that the burning must be "necessary" and may be conducted "only when an economical and reasonable alternate method of disposal is not available."

The State of Idaho, in developing "compliance schedules" designed to control open burning activities, has reviewed previously both the question of necessity and the availability of "alternative methods of disposal". None of these reviews resulted in reductions in acreage burned but did establish guidelines for the control of burning activities to reduce smoke effects and safety hazards. The last "compliance schedule" (Idaho Department of Health and Welfare, 1977) covering the period June, 1977 through December, 1981, provided for a continuing review of non-burning alternatives. However, no specific review had been completed when, in 1981, Idaho's Air Quality Bureau, the responsible regulatory agency, was temporarily dissolved.

With this background, it is intended that this analysis and report serve several functions. First, this document is proposed to fulfill the review process regarding alternative methods contemplated by the aforementioned regulations and "compliance schedule". Second, it is proposed to accumulate, organize, and document results of diverse research activities regarding the need to burn field residues and alternative methods of treatment upon which to base further judgments regarding the regulation of field burning. Finally, it is proposed that this document provide information to aid in the selection of methods to reduce emissions from open burning.

This report is not proposed to simply relate all investigation regarding burning and grass seed production but to present an analysis limited to information applicable to the Northern Idaho situation. Thus, research results or operational approaches used in areas distinct from the Inland Pacific Northwest seed producing region have been screened carefully as to their potential usefulness in reducing burning in Idaho. It should be made clear that this screening process was utilized to conserve resources rather than eliminate a potentially successful method for reducing emissions. Screening was applied only after a broad review of related investigations was first completed.

2.2 Information Sources

In compiling this report special efforts were made to collect information from a range of sources encompassing experiences beyond that of the Northern Idaho/Eastern Washington seed producing area. Of particular interest were the approaches to reducing burning of agricultural crops undertaken by regulatory agencies with air pollution problems paralleling those in northern Idaho. Far and away the bulk of efforts to reduce agricultural burning of crop residue have been centered in Oregon and California. Other states for the most part have not had to deal with the concentrated acreages subject to burning or have not had direct conflicts of interest occasioned by large amounts of open burning near population centers. As a result much of the information in this report is based upon research activities in these states where smoke control issues have led to extensive research sponsored by regulatory agencies. In the West and the South, smoke problems related to forestry burning have stimulated considerable research by the U. S. Forest Service and state forestry groups. Where this research or other operational procedures have appeared applicable to thhe Idaho situation, these sources of information have been drawn upon.

In seeking additional external perspective, sources in Europe and eastern states were contacted where grass seed production is an established industry. Though it was found that alternative crops and pricing structure make close comparison of cultural practices infeasible, these sources did help establish limits on practical alternatives to the present Idaho situation.

Finally, it has been recognized that much of the research on grass seed production to date has been sponsored and completed by university and industrial agricultural groups. The goal of much of this research has been to increase net seed yields while maintaining crop purity. In most instances, the use of open burning or some form of thermal sanitation has been supported by these research efforts. In fact, annual field burning was formalized as a cultural tool for grass seed production based on U.S. Department of Agriculture-supported research at

Oregon State University's School of Agriculture. Prior to the start of this report, there was concern expressed regarding the use of these same research institutions to evaluate the applicability of non-burning alternatives. In particular, there was concern that agronomic researchers, may be biased in analyzing alternatives to burning because:

1. Use of such alternatives may require acceptance of reduced yields or seed quality-a result in direct opposition to a goal of much of the previous research; and
2. The long, close association between agricultural research organizations and the grass seed industry make it difficult for such organizations to support alternatives that could make grass seed a less profitable enterprise.

To minimize the potential for any such bias to influence the conclusions of this report, the results of research supported by regulatory agencies were carefully weighed with those supported by agricultural interests. Where appropriate limitations or shortcomings of these research efforts are noted, a final conclusion was drawn by the author.

2.3 Grass and Grass Seed Industry Background

Though grass grows throughout the world and is adapted to a wide variety of climates, this background section will deal only with so-called cool season or cool climate grasses since Kentucky bluegrass is a member of this group. The several commercially significant species are often dichotomized into turf and forage catagories based on their growth habit, and usage. Turf type grasses are normally characterized by a relatively fine leaf and stem structure. Major varietal development efforts have aimed at improving green color retention; tolerance to shade; drought; traffic; diseases; and reducing maintenance requirements.

Forage grass often has a coarse, upright growth habit. Rapid growth and regrowth in response to cropping while maintaining high nutrition levels are critical attributes of forage grasses. Researchers have also sought improvements in drought and disease tolerance.

Table 2-I lists the commercially significant species of both turf and forage cool-season grasses.

Table 2-I

Commerically Significant Species of Cool-Season Turf and Forage Grasses Grown in the Pacific Northwest

TURF GRASSES

Red Fescue	(*Festuca rubra* L.)
Kentucky Bluegrass	(*Poa pratensis* L.)
Bentgrasses	(*Agrostis* sp.)
Fine-leaf Perennial Ryegrass	(*Lolium perenne* L.)

FORAGE GRASSES

Kentucky Bluegrass	(*Poa pratensis* L.)
Tall Fescue	(*Festuca arundinacea* Schreb.)
Perennial Ryegrass	(*Lolium perenne* L.)
Annual Ryegrass	(*Lolium multiflorum* L.)
Timothy	(*Phleum pratense* L.)
Orchard Grass	(*Dactylis glomerata* L.)
Meadow Fescue	(*Festuca pratensis* L. Huds)
Various Bromegrasses	(*Bromus* sp.)
Various Wheatgrasses	(*Agropyron* sp.)

Grass seed is grown throughout the world with various levels of sophistication and productivity. However, only in relatively few areas is grass seed the major crop. Significant production of cool season grass seeds, such as bluegrass, is limited to areas of Australia, Canada, New Zealand, Northern Europe (principally Denmark), and the United States. The development of these seed production areas is based on a variety of factors including agricultural and economic desirability or a substantial internal use of and, therefore, need for grass seed. To a greater or lesser extent, all have climatological conditions conducive to seed production.

Accurate data on production levels for these areas is limited. Only the U. S. (through 1981) and Denmark have reasonably detailed reporting of grass seeds produced. Significant species are shown in Table 2-II. Production levels for countries without specific amounts are believed to be significantly less than those of Denmark.

These seed producing areas compete against each other for the export market, principally Europe. The United States is by far the largest exporter of grass

Table 2-II

Major Cool-Season Grass Seed Producing Countries 1974-1978

Country	Major Species	Total Annual Production (millions of pounds)
United States	Annual Ryegrass Tall Fescue Perennial Ryegrass Kentucky Bluegrass Orchard Grass Fine fescues	426.6
Denmark	Perennial Ryegrass Annual Ryegrass Fine Fescues Bluegrass Orchard Grass Tall Fescue	93.1
Canada	Fescue Bluegrasses	---
New Zealand and Australia	Annual ryegrass Perennial Ryegrass	---
Other EEC Countries (France, West Germany, Belgium, The Netherland, United Kingdom)	Annual Ryegrass Perennial Ryegrass Fescues Kentucky Bluegrass	---

seeds of any nation with about 15 percent of its total production dedicated to this market. (Wilson and Conklin, 1981)

2.3.1 U. S. Grass Seed Industry

2.3.1.1 Areas of Production/Types of Seed Produced

Though some cool season grass seed production occurs throughout the United States, significant seed production areas are limited to the Pacific Northwest states of Oregon, Washington, and Idaho, and Minnesota, Missouri, Kentucky, and Kansas. Oregon is far and away the largest producer of grass seed due principally to its near monopoly of ryegrass seed production which accounts for approximately 57% of all grass seed produced in the U. S. Oregon accounts for about 36% of the total grass seed acreage in the U. S. and about 70% of the total production of clean grass seed. Missouri, also with about 36% of the nation's grass seed acreage, produces about 16% of the seed, almost all tall fescue. The great disparity in production per acre reflects the higher yielding ryegrasses grown in Oregon as well as the generally higher yields achievable in the Pacific Northwest. Table 2-III gives average annual clean seed production for major producing states of cool season grass seeds. As may be seen, the Pacific Northwest states account for nearly 78% of total production.

National Kentucky bluegrass seed production is even more concentrated in the Pacific Northwest with 93% of Kentucky bluegrass seed being produced in this area at present. Of the remaining 7%, most is produced in Northern Minnesota. Production on the average has been evenly divided among each of the Pacific Northwest States and all other states as illustrated in Figure 2-1.

2.3.1.2 General Quality Requirements

Quality criteria for grass seed fall in three general areas:

1. Genetic purity;
2. Level of germination; and
3. Freedom from unwanted seed types and inert materials.

Satisfying appropriate criteria in each of

Table 2-III

Average Annual Production of Cool Season Grass Seed for Major Producing States, 1979-1981
(millions of pounds of clean seed)

States	Annual Ryegrass	Perennial Ryegrass	Tall Fescue	Kentucky Bluegrass	Timothy	Orchard Grass	Red Fescue	Bentgrass	Total
ARK			3.7						3.7
IDAHO				12.6					12.6
KANSAS			3.9						3.9
KY			4.1			0.2			4.3
MINN					11.9				11.9
MO			71.9		1.0	0.8			73.7
OREGON	198.1	59.7	8.2	16.5		12.4	15.2	5.9	316.0
WASH				15.7					15.7
TOTAL	198.1	59.7	96.5	44.8	13.4	13.4	15.2	5.9	442.0
Percent of Total U.S. Production	100	96.5	100	93	91	95	100	100	

these catagories specifies to the consumer the quality and value of the product purchased and does much to minimize the role of point of origin in selection.

Genetic purity requirements are normally satisfied by limiting the number of generations between product seed and original breeders' stock. This is limited to only three or four generations. Original breeder stock seed is distributed to specially selected growers who plant it and produce "foundation" seed. Foundation seed is in turn planted with the subsequent generation termed "registered" seed. This registered seed is purchased by seed growers for production of the "certified" seed eventually purchased by consumers. (Garrison, 1960) To maintain acceptable genetic purity, certified seed may not be planted for seed production purposes except as uncertified seed. (Idaho Crop Improvement Association, 1982) Therefore, maintenance of a uniform generation field is important if the more profitable certified seed is to be grown. Such considerations are of particular importance for grass seed

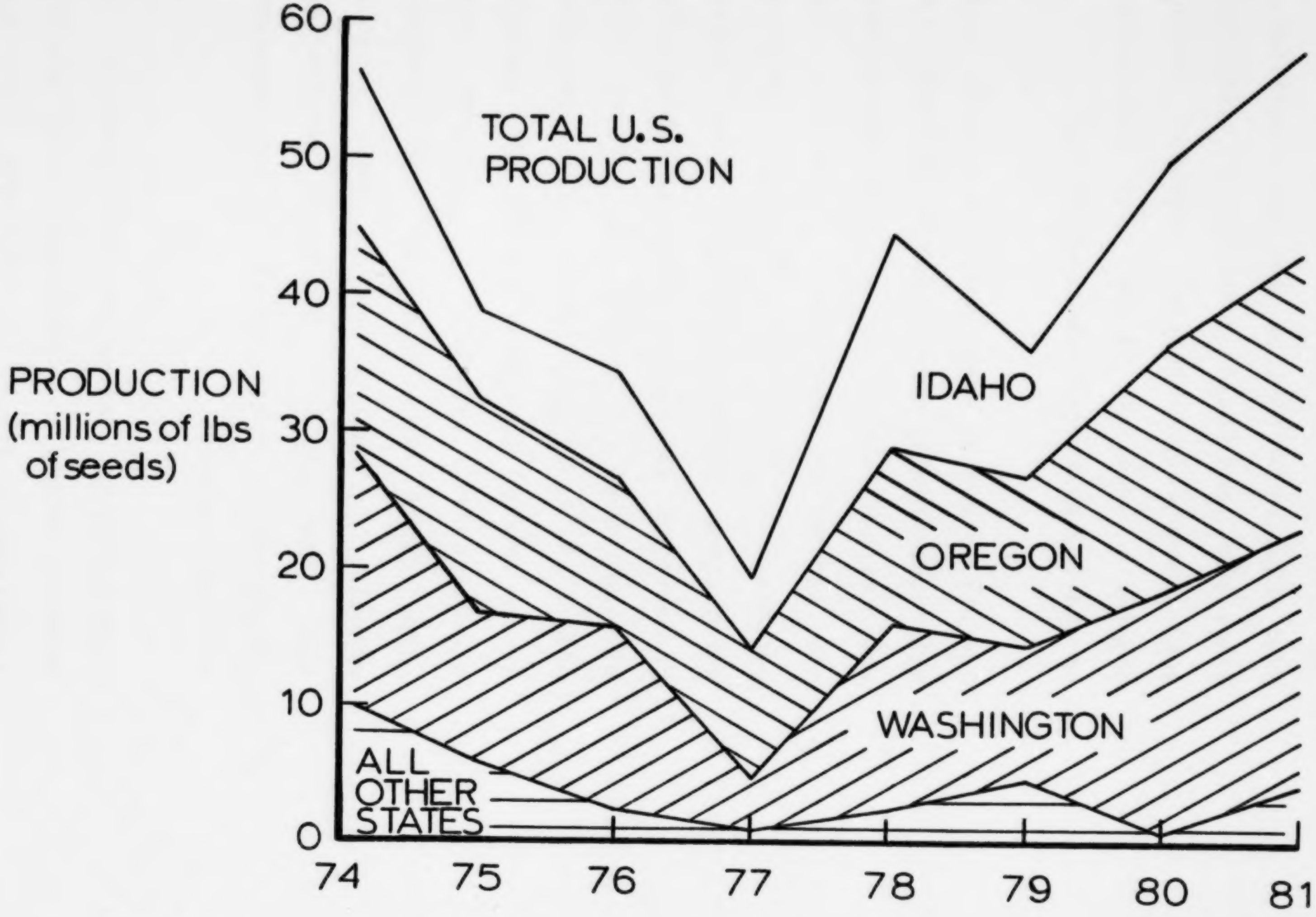

Figure 2-1 United States Kentucky Bluegrass Seed Production, 1974-1981.

varieties that tend to "shatter" or drop seed prior to or during harvest operation. Since such seed could conceivably germinate and eventually produce unwanted fifth generation seed, it is of some importance to control shattered seed germination.

The percentage of seed that is viable and will successfully germinate is critical to the consumer since it in part determines the amount of seed that needs to be purchased. Most grass seeds provide germination rates above 90% with lower percentages adversely affecting salability of the crop. A number of factors can affect the final germination value achieved in the product including growth and harvest circumstances, incidence of disease and other pests and transport and storage methods. Obviously, any of these factors that significantly affects germination values and is controllable is of interest to seed producers.

Seed purity is determined and recorded in order to establish compliance with quality requirements since the customer is not interested in buying off-variety seed types, inert materials, or problem seeds along with the desired crop seed. Of particular concern are seeds of noxius weeds (either poisonous or non-poisonous) or diseased seeds. Either general class of seed presents a potentially serious problem for the consumer. Consequently, regulations regarding impurity in seed crops set specific, and often severe, limitations on noxius weed seed and diseased seed in the final product.

2.3.1.3 Use of Burning in Grass Seed Producing Areas. Because of its utility in controlling a number of factors tending to reduce seed quality, the burning of post-harvest stubble is a common practice. In fact, such burning is standard procedure in all areas where grass seed is the principal crop. An exception to the routine practice of burning occurs in Missouri and other states where tall fescue is grown extensively for forage purposes. In seasons when it appears economically advantageous, a seed crop will be taken from these pastures as a by-product to cattle production. The relatively low quality seed produced is subsequently processed and used for reseeding of pastures. Burning can not be conducted since it substantially reduces the forage available for fall pasturing. (Wheaton, 1982)

The use of burning in grass seed production is strongly influenced by local climatology. It appears that much of the agronomic benefit of burning is lost if it occurs when the grass plant is not in a fully dormant state such as normally exists in the dry, post-harvest summer months of the far west. If an actively growing plant is burned, adverse physiological responses are noted, resulting in yield reductions. This effect has been demonstrated in studies on early versus late burning in the Pacific Northwest. (Chilcote and Youngberg, 1975) Also, in European seed growing areas where summers are much wetter than in the western U.S., seed production response of the plants to burning is very much reduced. As a consequence, burning of post-harvest residues is not common practice in Europe. In Australia and New Zealand where climatic conditions resemble those of the near-coastal areas of the northwest U.S., burning of grass seed residues has found favor and is recommended by local grass seed experts. (Youngberg, 1982; Hebblethwaite, 1982)

Farm economics also significantly influence the selection of burning as an integral part of grass seed culture. In many areas (for example, Missouri) grass seed is a secondary crop or by-product to the preferred enterprise. Typically this is due to lower profits associated with grass seed as opposed to cereal or roww crop alternatives or livestock production. In some areas, grass seed is grown only as a short rotation crop for the more predominate money makers. As a result, even turf-type perennial fields have no long-term production potential. Such is the case in most of the grass seed production areas of Europe.

Under such short production cycles, (for example, two seed crops) burning becomes much less significant as a cultural tool for maintaining yields and controlling diseases. Routine cultivation associated with changes in crops normally is effective in controlling disease problems. Also, cool season grass seed varieties normally produce their maximum yields in the first two harvests and subsequent yield reductions that might occur without burning are of no concern.

To put it simply, the long term production of low cost, high quality grass seed does not have the high priority on farm operations where grass seed is a secondary crop as it does on operations where it is a principal source of income. As a result, the necessity for and use of burning is significantly less in areas where grass seed is a minor or incidental crop, even if the cumulative acreage is large.

2.3.1.4 Grass Seed Marketing

National grass seed sales occur in an essentially free market setting. Prices respond to the supply of seed (annual production and stocks) and demand. There is relatively minor economic interaction between the various grass species; however, Kentucky bluegrass varieties are normally separated into, at least, proprietary and public variety groupings from an economic perspective. Proprietary varieties are those varieties developed by individuals, corporations, associations or similar entities who retain control of their production and marketing. Since most proprietary varieties have been developed for turf production, there is an implied association between the term proprietary and thesee relatively low yielding turf varieties.

Grass seed normally is produced by independent growers and moves through processors and dealers into the market. A number of large companies conduct all functions while others serve only as processors and marketers. In Oregon there are numerous small grower/processors who deliver the seed in a form suitable to the end user.

Because of the free market regulation of prices, seed growers have little direct control in setting prices of their product. Prices tend to show considerable variation from year-to-year. These swings reflect seasonal weather conditions and grower acreage decisions, as well as previous demand, current demand, and consumer planning and optimism. There exists only an indirect link between production costs, which tend to change predictably, and prices received. As a result the profitability of grass seed, like other farm commodities, varies greatly from year-to-year. Figure 2-2 illustrates the price variation for selected grass seed crops and areas.

2.3.2 Northern Idaho and Eastern Washington Grass Seed Industry

In the last two decades the Inland Pacific Northwest has become well established as a producer of high quality grass seed. Though much of the initial growth was through the efforts of a single seed producer/processor, there are now over two hundred seed growers involved. About 44,000 acres were in production during 1982, a figure which, until recently, has shown continued growth.

Unfortunately, much of the grass seed acreage is located near populated areas where growth has matched that of the seed industry. Now grass seed field and residential neighborhoods

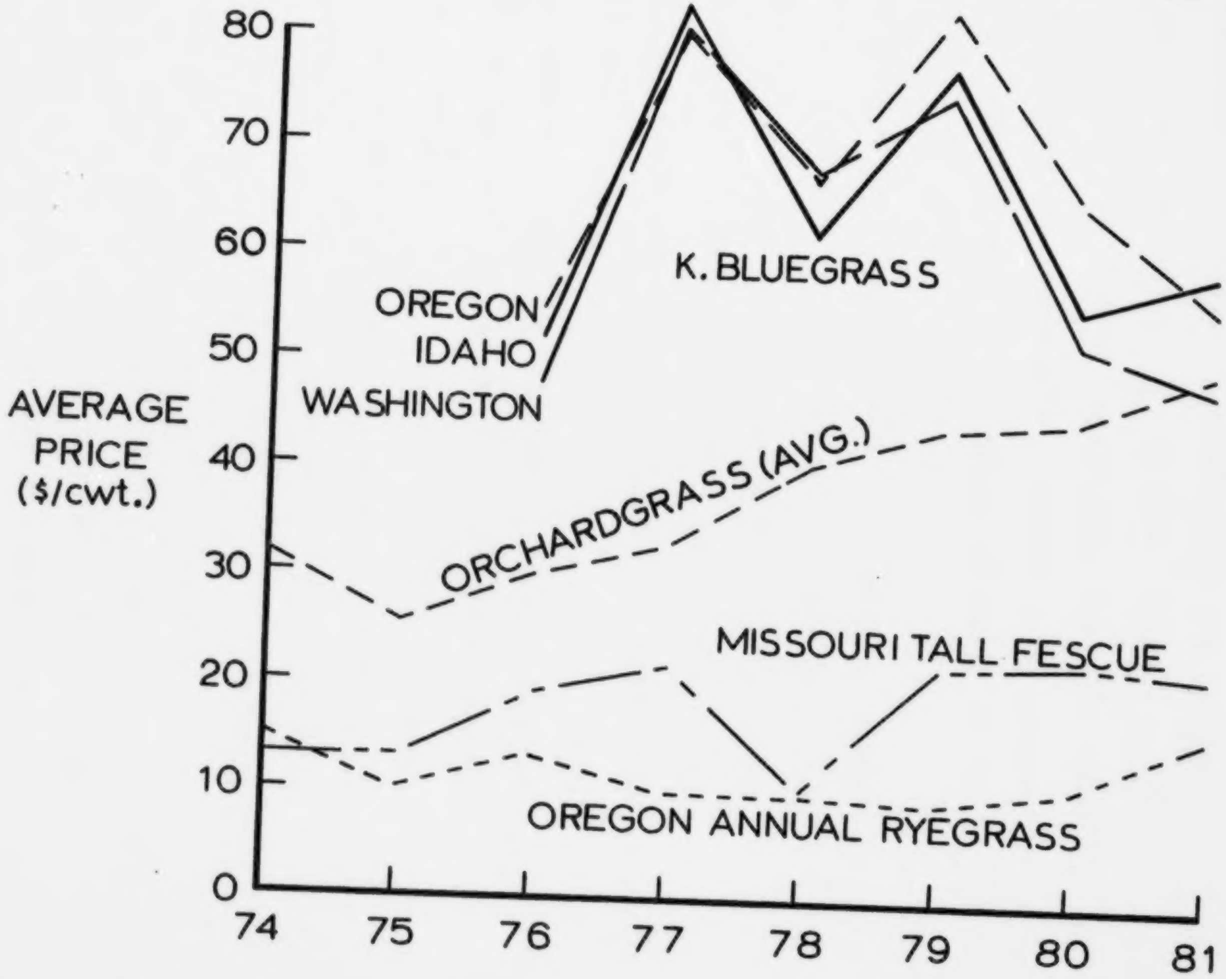

Figure 2-2 Average Price Received for Various Grass Seeds, 1974-1981.

are juxtaposed in many areas and uncomfortably close in others. Under this circumstance, the annual burning of seed fields with its attendent air contaminants results in serious public outcry. Also it is perceived by some that the air pollution caused by the open burning of fields adversely affects the tourist trade of nearby resort communities.

Though efforts have been undertaken by local and state air pollution control agencies and the Intermountain Grass Growers Association to ameliorate smoke effects through a burn management program, problems still exist at a level which elicits significant public concern. Also research efforts, conducted through local universities under the aegis of various groups, have not arrived at alternative methods to burning that would significantly improve the air pollution problem.

2.3.2.1 General Production Information

Grass seed production in the Inland Pacific Northwest area is almost exclusively Kentucky bluegrass (Poa pratensis L.). Though other varieties of grass seed are grown, Burt and Wirth (1976) reported that, in 1969, some 92% of the grass seed produced in Washington and Idaho was Kentucky bluegrass. Kentucky bluegrass acreage in the area has increased significantly since 1969.

Local climatology and economics argue strongly for selection of Kentucky bluegrass. Warm, dry summers and cold, moderately wet winters produce conditions suitable for Kentucky bluegrass seed production. In addition, soils are generally good with good to excessive drainage. These factors allow bluegrass yields to be among the highest of any area. However, yields of the major competing area, Oregon, are also high. (USDA Crop Reporting Board, USDA, 1979 and 1982) In addition to these physical factors, the Kentucky bluegrass seed industry of the Inland Pacific Northwest has a well-established local processing and marketing infrastructure.

Areas of major Kentucky bluegrass production are illustrated in Figure 2-3. As may be seen, grass seed production is centered in

Spokane County, Washington, and Kootenai and Benewah Counties of Idaho. Though grass seed is grown in surrounding areas, by far the largest concentration of production is located in these three counties. Also, the effect of field burning in these surrounding areas, on air quality in populated areas, is very small and has not become a public issue.

As may be seen from Figures 2-3 and 2-4, acreage has been essentially evenly split between the two states. Kentucky bluegrass acreage amounts experienced general growth during the late seventies. However, this growth has reversed during the last three seasons, reflecting somewhat lower prices and, most recently, sharply lower demand.

Though Kentucky bluegrass is by far the predominant species grown in the area, a large number of varieties of the crop are in production. Both public and proprietary varieties are grown with Idaho traditionally having roughly half of its acreage dedicated to the higher priced proprietary varieties. Washington, on the other hand, has had no more

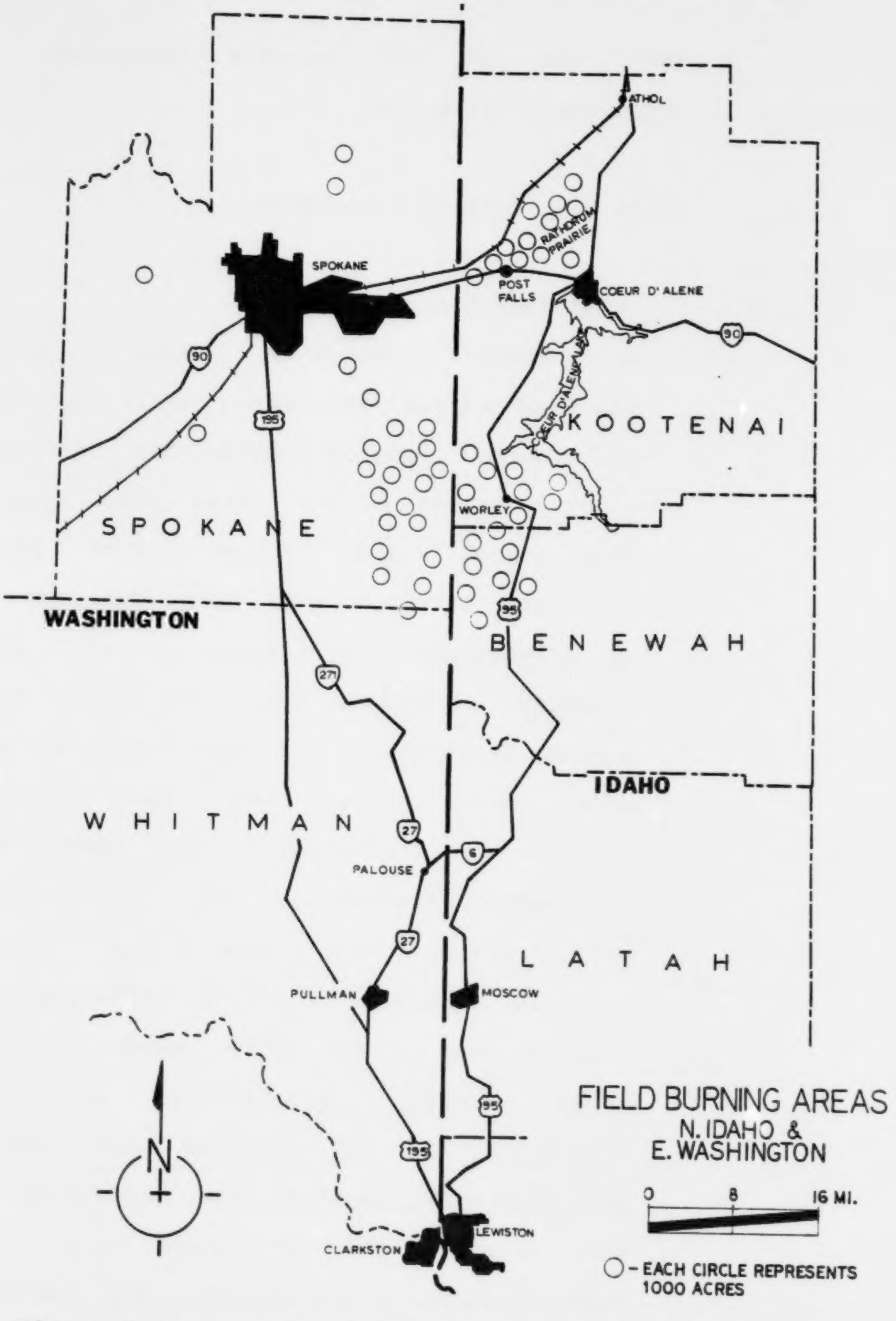
ATHOL
RATHDRUM PRAIRIE
SPOKANE
POST FALLS
COEUR D' ALENE
90
COEUR D'ALENE LAKE
KOOTENAI
195
WORLEY
SPOKANE
WASHINGTON
95
BENEWAH
27
IDAHO
WHITMAN
27
PALOUSE
6
27
LATAH
PULLMAN
MOSCOW
95
195
N
LEWISTON
CLARKSTON
FIELD BURNING AREAS
N. IDAHO &
E. WASHINGTON
0
8
16 MI.
○ - EACH CIRCLE REPRESENTS 1000 ACRES

Figure 2-3 Kentucky Bluegrass Seed Producing Areas in Northern Idaho and Eastern Washington.

than 20% of all acreage committed to proprietary varieties.

2.3.2.2 Idaho Crop Quality Requirements

2.3.2.2.1 Grass Seed Crops

As noted previously, seed quality requirements are generally quite rigorous. Each state normally establishes its own quality standards for seeds used within that state, either through direct state regulation development or identification of an appropriate organization to set such standards and regulations. In Idaho, seed quality requirements are set forth in the Idaho State Seed Law and related certification procedures of the Idaho Crop Improvement Association, Inc. Grass seed certification regulations in Idaho establish standards regarding virtually all factors that could affect seed quality. These include regulations on the eligibility of the proposed seed variety and field site, handling and inspection of the crop, field isolation, and seed handling,sampling, inspection, and tagging.

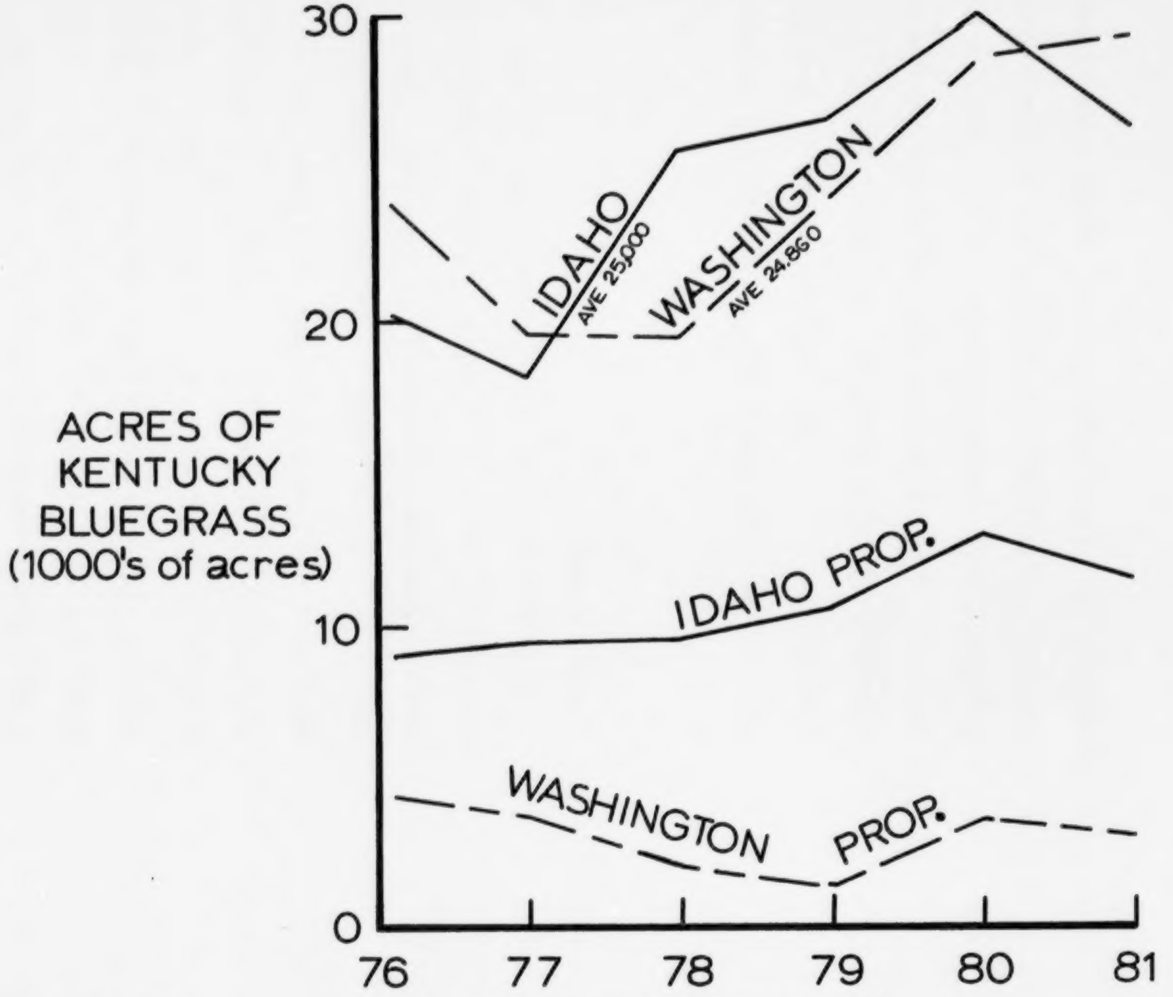

Figure 2-4 Acreage in Seed Production for All Varieties and Proprietary Varieties of Kentucky Bluegrass in Idaho and Washington, 1976-1981.

Table 2-IV summarizes Kentucky bluegrass seed certification requirements from these regulations.

As may be seen from Table 2-IV, stringent purity requirements apply to grass seed proposed for certification. Of particular concern are limitations on weed content, especially of noxious weeds where any appearance in a sample can prevent certification, resulting in a reduced price.

2.3.2.2.2 Cereal Crops

Cereal crops are also inspected prior to marketing with ultimate grade depending upon numerous subjective quality factors and, to a lesser extent, impurities. Grains are graded into one of four or five classes based upon species. "Certification" of grain does not occur except for grain crops grown for seed. However, like loss of ceritfication, lower grade grain results in lower market prices.

It is an accurate generalization that

Table 2-IV

Summary of Selected Idaho Seed Certification Requirement for Kentucky Bluegrass

Eligible Varieties(a)

A-34
Adelphi*
Arboretum
Argyle*
Baron*
Birka
Bonnieblue
Bristol
Cheri
Delta
Eclipse
Fylking*
Galaxy
Geronimo
Glade
H-7
Holiday*
I-13
Kenblue
Majestic
Merion*
Newport*
Nugget
Parade
Park*
Pennstar
Plush*
Ram I
Sydsport
Touchdown
Victa
Wabash

Land and Field Eligibility

	Foundation Seed	Registered Seed	Certified Seed
Years since same species last grown or seeded in proposed field	5	2	1
Isolation distance (feet) from same species which bloom at the same time	160	32	16
Occurance of off-variety plants in field as may be identified by normal inspection procedures	none	0.5%	1.0%

a. Varieties noted with an asterisk (*) are under the four class generation system (Breeder, Foundation, Registered, Certified). All other varieties are under the three class generation system (Breeder, Foundation, Certified).

Table 2-IV (continued)

Seed Standards

	Sod Quality Seed	Foundation Seed	Registered Seed	Certified Seed
Minimum percent pure seed	97[e]	97[b]	97[b]	97[b]
Maximum percent inert matter	3[c]	3[c]	3[c]	3[c]
Maximum percent weed seed[h]	0.02[g]	0.5	0.5	0.3
Maximum percent other crop	0.1[d,f]	0.1[d]	0.1[d]	0.5[d]
Minimum percent germination	80	80	80	80

b. Merion Kentucky Bluegrass: 92%
c. Merion Kentucky Bluegrass: 8%
d. Other K. Bluegrass varieties in Merion: 3%; in other than Merion: 2%
e. Merion Kentucky Bluegrass: 95%
f. Must be free of numerous specified coarse grasses
g. Must be free of dock, chickweed, crabgrass, plantain, short-awn foxtail, black medic, annual bluegrass, velvetgrass
h. Must be free of noxious weed identified in Idaho General Seed Standards Section VII, paragraph C.

purity and quality standards for grains for general marketing are signficantly less stringent than those that apply to seed crops. There are no requirements regarding genetic purity, and tolerances of inert and non-crop materials are much greater. Tolerance of weeds is very broad compared to seed crops.

The net effect of these regulations is that, compared to cereal grains, seed crops require greater attention to field and establishment details to maintain genetic purity and overall seed quality. However, it is still necessary to insure an adequate yield of live seed to cover production cost. In the case of perennial crops such as Kentukcy bluegrass, this attention to detail must be maintained throughout the multi-year life of the stand.

2.3.2.3 Use of Burning and Burning Problems in Idaho

Almost without exception, Idaho Kentucky bluegrass fields are burned each year after harvest. As will be reviewed in Section 3, this practice produces a number of substantial agronomic benefits which has supported its routine use in a number of seed growing areas. As noted earlier, some 40,000 acres of grass seed are burned each year in areas identified in Figure 2-3. In addition to grass seed burning, some 5,000 acres of cereal crop residue, mostly wheat, is burned each year. This latter activity has been found to be an effective short-term solution to reduce residue removal costs and has been concentrated in the Rathdrum Prairie where, due to soil conditions, straw and stubble incorporation is expensive.

The most obvious adverse affect of this burning is the huge quantity of air contaminants released which can become a source of air pollution in downwind areas. The cities of Spokane, Washington and Coeur d'Alene, Idaho have been impacted each year as well as smaller cities and resort communities. Smoke intrusions in these areas have resulted in citizen complaints. Seasonal totals of these complaints have tended to increase over the last several years, a trend illustrated in

Figure 2-5. Other adverse effects of burning on air quality include increases in particulate loading, odors, ash fallout, and reductions in visibility. None of these effects violates specific laws or regulations relating to air quality control. However, most of the effects cause a significant nuisance and, in some circumstances, health or safety problems. A small percentage of individuals appear to have great sensitivity to the fine particulate and/or gaseous elements of field burning smoke which causes the onset of severe physical discomfort when they are exposed. Sufferers of asthma and emphysema appear to be especially affected. Often complainants report of discomfort due to headache or eye irritation. (Gray, 1981)

Traffic safety is of particular concern near major highways and airports where smoke reduces visibility. Special air traffic control precautions are implemented whenever visibility is reduced to three miles or less, while automobile traffic is impeded only when visibility is less then one-fourth mile.

2.3.2.4 Relationship of Grass Seed and Cereal

Crops-Typical Cropping Patterns

Cropping patterns of the Kentucky bluegrass growing area vary somewhat depending upon soils and farm resources, but in most areas grass seed and cereal crops may be grown interchangeably. Under such circumstances, economic consideration dominates the selection of either crop. Since grass crops require a longer-term commitment of the acreage than the annually cropped cereals, as well as some specialized harvest equipment, a farmer must consider carefully these investments, potential income, and lessened liquidity of his land prior to initiating bluegrass seed production. Occasionally, short- or intermediate-term concerns for profits may be modified based upon a need to protect or properly utilize existing soil conditions. Acreages with significant slopes may be subject to excessive erosion under an annual cropping pattern so that a more permanent crop is required to reduce soil loss. Occasionally, root diseases may dictate routine crop changes and tilling for control.

Given these types of general concerns, cropping patterns involving Kentucky bluegrass

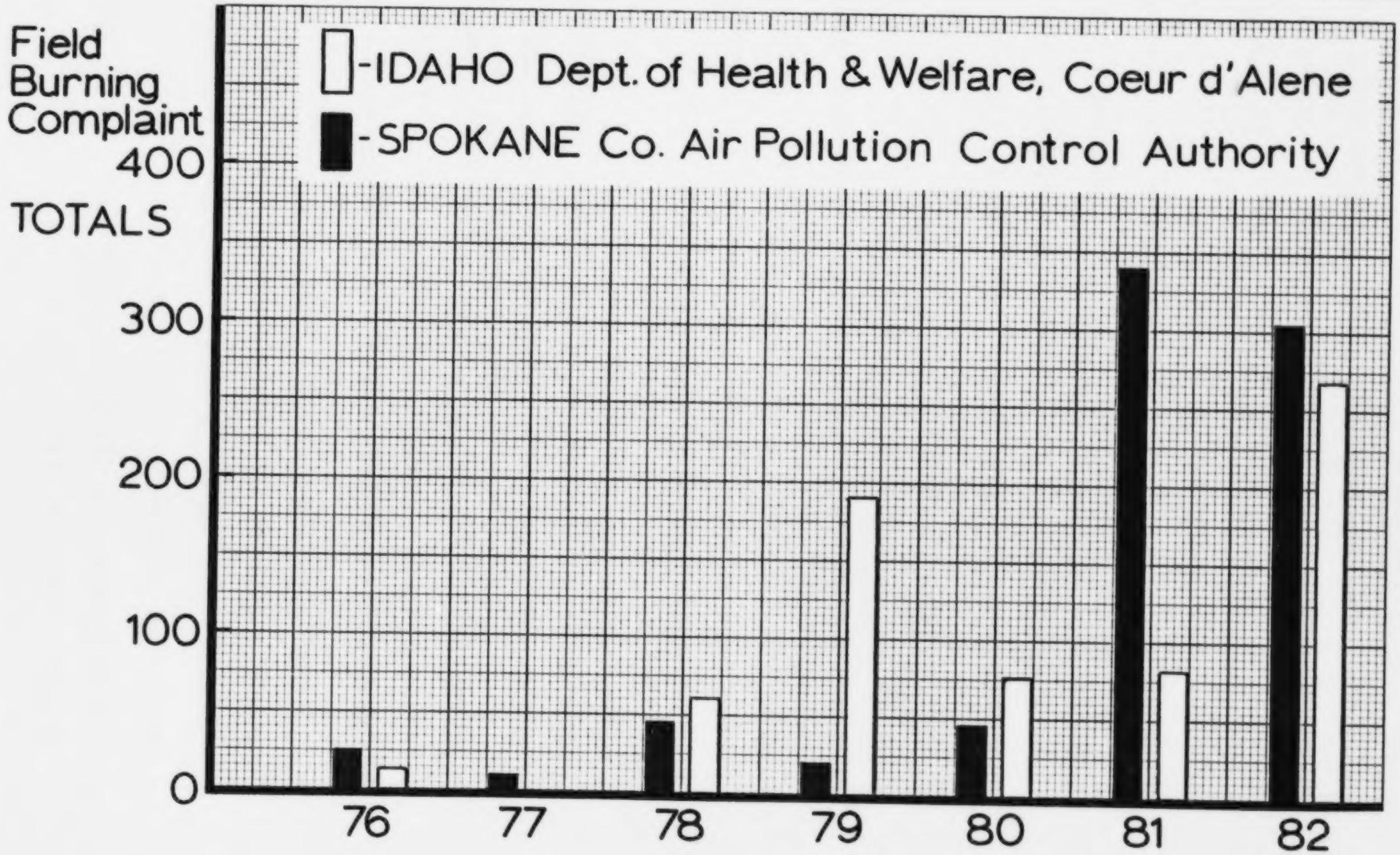

Figure 2-5 Field Burning Related Complaints Received by Air Quality Regulatory Agencies in Idaho and Washington, 1975-1982.

are highly influenced by two factors:

1. The availability of irrigation; and
2. The relative prices of wheat, or other alternative crops, and Kentucky bluegrass.

Of course, once Kentucky bluegrass has been selected, there is a strong tendency to maintain the stand in order to amortize the comparatively high costs of establishment. Accordingly, a stand life of five to seven years is common for fields that have been routinely burned. (Wirth, Burt, Canode, and Law, 1977) Some Kentucky bluegrass fields have been in continuous production in excess of fifteen years. (Youngberg, 1982)

A convenient separation of Kentucky bluegrass producers is made by considering farms where seed production is a major enterprise (more than 25% of sales derived from Kentucky bluegrass) and those where seed production is a minor enterprise (less than 25% from grass seed). Studies by Burt and Wirth found 55% of growers in the Inland Pacific Northwest Kentucky bluegrass area to fall into the "major" category using this scheme. (Burt and Wirth, 1976 and 1979)

Cropping patterns when considered on a field basis, are similar. Fields normally stay in production for at least six years before rotating to other crops. "Minor" seed growers will leave a field out of production for three to eight years while this period is on the order of four years for farms where grass seed is a major enterprise. For all growers, wheat is the major alternative crop, though barley, peas, and lentils are also rotated. (Burt and Wirth, 1979) It was also noted that major enterprise growers accounted for an overwhelming percentage of the proprietary varieties grown in the area.

2.3.2.5 Idaho Grass Seed Marketing

In the marketing of grass seed in Idaho, like other areas, the free market prevails. However, almost all seed is processed and marketed through relatively few major commercial processors to distributing wholesalers. Individual contracts, when prepared, are written between these dealers and growers. Growers of proprietary varieties deal with the proprietor either directly or through the designated local dealer.

Prices for Idaho seed are established by free marketing principals with Idaho seed competing against Kentucky bluegrass seed from Washington and Oregon. Since Idaho and Washington production areas adjoin one another, they are subject to similar growing conditions, alternative crop choices, and economic factors, and similar decisions regarding production would be expected. This is in fact the case, as illustrated by Figure 2-6, which shows percentage swings in annual production. As may be seen Idaho and Washington changes track closely with one another. As may also be seen in Figure 2-6, acreage shifts in Oregon do not follow the Idaho-Washington pattern and, in fact, are much less dramatic. Significantly different growing conditions, crop alternatives, and economic conditions of western Oregon has resulted in this much different production pattern. In particular, yields in western Oregon can vary dramatically from those of the Inland areas. Since in general prices will respond to the overall supply of and demand for Kentucky bluegrass on a national and international basis, the role of Oregon

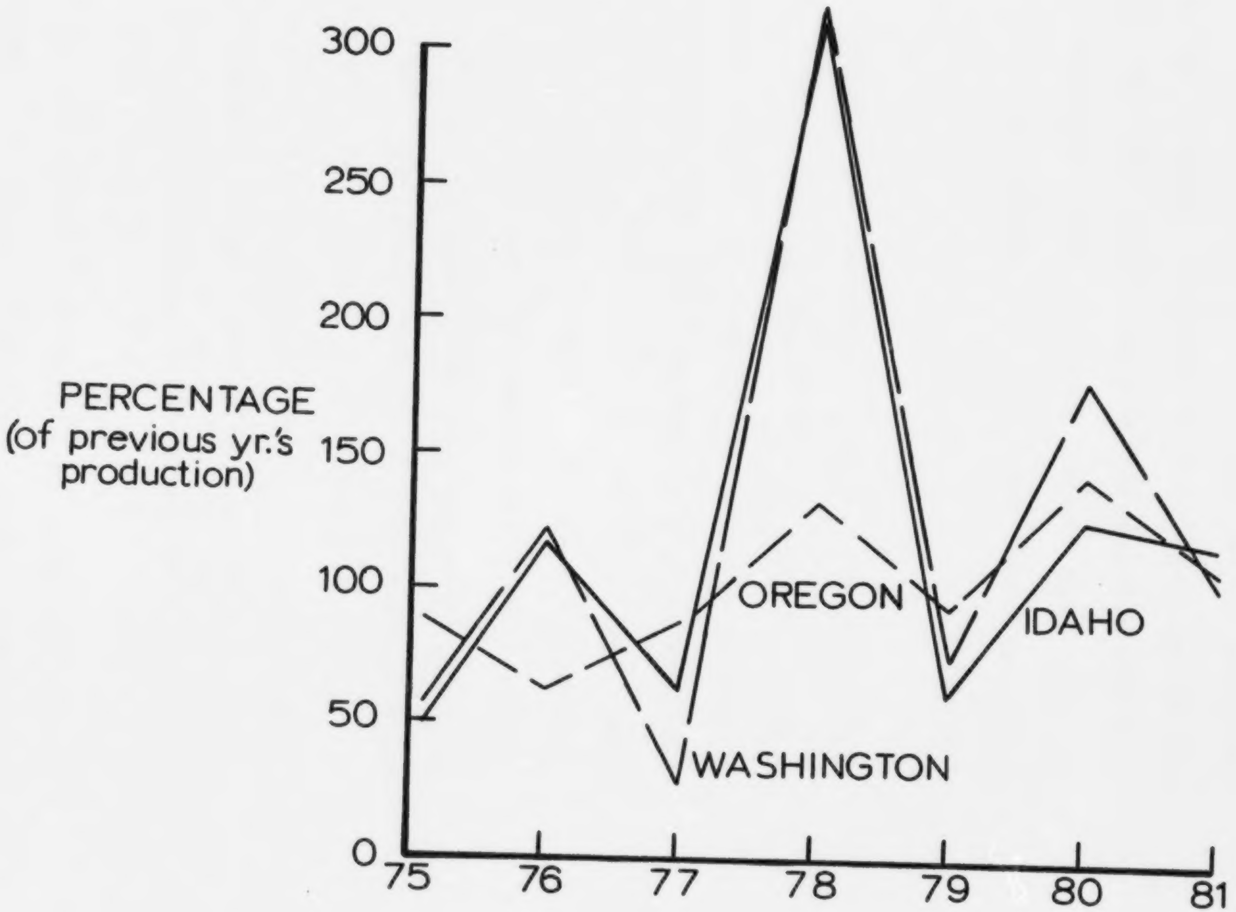

Figure 2-6 Kentucky Bluegrass Seed Production as a Percentage of the Previous Year's Production for Idaho, Oregon, and Washington, 1975-1981.

bluegrass seed production can be significant in affecting prices. Proprietary varieties, popular in Idaho and Oregon, are produced and marketed under much more controlled and highly specified arrangements than common varieties and do not seem to significantly affect market movement and overall prices. This may be due to the fact that prices for proprietary varieties often are tied to those of common varieties.

The supply of Kentucky bluegrass is largely a matter of prevailing seed prices and the prices of alternative crops. In Inland areas, the principal alternative crop is wheat with peas and lentils as secondary alternatives. In Oregon, wheat and other perennial grasses are primary alternatives, while row crops and nursery stock may be alternatives on acreage with irrigation. As noted earlier, the need to amortize the high cost of Kentucky bluegrass establishment mitigates in favor of its retention, even when short-term profitability would favor an alternative crop.

Major end-uses of Kentucky bluegrass include home and golf course turf, pasture establishment, and export. Internal use for turf is dramatically affected by factors which affect construction in general; that is the availability and cost of money. As new housing starts drop, so generally will Kentucky bluegrass prices. Export quantities of seed are affected by U. S. prices, the rate of exchange, and external supply and reserves. An econometric model has been developed incorporating these variables to better discern the structure of the U. S. Kentucky bluegrass seed industry. (Folwell, Burt, and Wirth, 1978)

This model showed strong interaction between Oregon and Inland Kentucky bluegrass seed production. In an examination of the effects of reduced yield, such as those attributable to reduced burning, this model predicted long-term increases in acreage stimulated by producer-anticipated higher prices. The model also showed Inland acreage amounts to be much more responsive to yield variation and other stimuli than Oregon acreage amounts. Also, U. S. Kentucky bluegrass prices responded more dramatically to changes in Inland supply than similar changes in Oregon supply.

2.3.2.6 Kentucky Bluegrass Seed Production

In assessing the need to burn, it is important to understand the annual production cycle for perennial grass seed. In addition, to assess the economic consequences of reduced burning, it is of importance to understand how fire is utilized to reduce costs, what costs alternatives to burning may involve, and what elements of the production cycle are most significant from an economic and cost perspective. To help understand the subsequent discussion of these issues, this section presents a summary of the activities involved in the production of Kentucky bluegrass seed.

2.3.2.6.1 Planning for Seed Certification

Certification is a necessary part of the seed industry. Since the production of certified seed offers real financial rewards to the seed grower over non-certified seed, it is important to consider the requirements of a successful certification program, especially during the establishment period. Of primary importance in establishing a certifiable stand of Kentucky bluegrass is the use of an approved stock seed (either foundation or registered) for sowing. Since Kentucky bluegrass (Poa pratensis) has several varieties, a selection of cultivar must be made based on marketability, predicted or known adaptability to seed production in the Inland Pacific Northwest, cost of production, seed prices, experience, and other factors.

Choice of the field requires some special precautions when planning for a certified seed crop. In particular, the plot of ground selected for certified Kentucky bluegrass must have a record indicating the crop history of that field. No other varieties of Poa pratensis may have been planted in the field during the last two seasons. This essentially precludes the mixing of the new crop of Kentucky bluegrass with the plants resulting from surviving seeds or plants from previously established Poa pratensis varieties.

To further minimize the potential for

mixing with other varieties of *Poa pratensis*, the new field must be isolated from any such surrounding fields. Because Kentucky bluegrasses largely are apomictic, crossing with other nearby plants is only of minor concern; therefore, the minimum distance required for isolation is only sixteen feet. (Idaho Crop Imrovement Association, 1982 and Brewer, 1976)

Once a field has been selected, its history must be presented to certification personnel who also will inspect the field for compliance with certification qualifications. Field inspections will be made within sixty days of planting and prior to harvest each year. Plans must also be made for qualified seed cleaning, sampling, and certification testing. Final testing will be completed by appropriately qualified seed certification laboratories in each state and tags affixed by Association or county agent representatives. (Long, 1982)

2.3.2.6.2 Crop Establishment

Soil Preparation

If unknown or if not acquired recently, a soil analysis would normally be obtained from a testing laboratory to determine any soil deficiencies prior to planting. A pH test is fundamental. Previous studies in Oregon have shown that Kentucky bluegrass produces satisfactorily in soils of pH 5.3 to 5.7 and neutralization to higher pH's showed no appreciable improvement in seed quality or yield. (Rampton, Jackson and Lee, 1971) Treatment with lime does not appear necessary if soil tests indicate this degree of acidity and is not normally required in Inland areas. (Van Slyke, 1982) However, sucessive application of nitrogen fertilizers will tend to depress the pH with time.

Other soil deficiencies in either phosphorous, potassium, or sulphur are corrected at the time of seeding by banding and later by broadcasting. Trace element (calcium, magnesium, etc.) deficiencies may be corrected at the time of seedbed preparation and worked into the soil.

The seedbed is generally prepared by plowing followed by some form of pulverizing operation. A firm, fine seedbed is the desired final state prior to planting with soil supplements thoroughly integrated.

Planting

Many studies have been made examining the most efficient width of row spacing for various grass types. (Rampton, et. al., 1971; Austenson and Peabody, 1964; Canode, 1968; and Roberts, 1961) Rampton, Jackson, and Lee (1971) found twelve-inch spacing to be superior under all circumstances to 30-inch rows for Newport Kentucky bluegrass while Canode (1968) found higher average yields in 30 and 60 cm (11.81 and 23.62 inches) over 90 cm (35.43 inches) spacing for Cougar Kentucky bluegrass. The Cooperative Extension Service in Western Oregon(Gardner and Warren, 1969) indicates a drill width spacing of twelve to fourteen inches as optimum for that area.

A sowing depth of one-quarter to one-half inch (6.2-12.5 mm) has been found satisfactory for Kentucky bluegrass and fertilizer banding at this time has been found to increase seedling vitality. Applications of twenty to forty pounds of nitrogen per acre sometimes are recommended in this manner. Also, phosphorous and potassium can be applied in the band if soil tests indicate the necessity.

Seeding rates of three pounds per acre are generally accepted, but rates will vary on the availability of approved stock seed. (Garrison, 1960, and Brewer, 1976)

Fertilizing

Generally, Kentucky bluegrass is fertilized at establishment and each year thereafter. Fertilizer is applied in the fall, spring, or split between fall and spring. Nitrogen is most critical to maximizing yield potential. Canode (1968) found 100 pounds per acre of nitrogen to give highest yields for the first two seasons, but the highest five-year mean yield was produced by application rates of eighty pounds per acre. It is generally thought that when more moisture is available, higher nitrogen rates can be used satisfactorily. (Canode, 1972; Evans and Canode, 1971) However, care must be exercised since spring application and/or high rates of nitrogen (greater than 100 pounds per acre) can cause premature lodging and seed loss unless cold weather retards growth. Fertilizer rates often are increased in older stands to maintain yield. (Gardner and Warren, 1969)

Weed and Pest Control

Weed control can take many forms but, generally, crop rotation, cultivation, roguing, burning, and chemical controls are most important. Of course, with any perennial grass stand, crop rotation is eliminated for the three to ten year life of the stand. Also, cultivation of established bluegrass fields has been shown to reduce yields. (Canode, 1972)

For Kentucky bluegrass or other perennial grass seed crops, weed control is critical at the time of establishment. During planting operations, pre-emergence application of herbicides is often used effectively. Seedlings may be protected by activated carbon banding. (Lee, 1973) Broadleaf weed killers are used in seedling stage grass stands after the third or fourth leaf stage has been reached by the grass plant. (Garrison, 1960)

2.3.2.6.3 Stand Maintenance

Weed and Pest Control

Control of off-variety plants, weeds, and pests is critical to the maintenance of seed quality and certification. Normally a combination of burning and chemicals are used. For widespread problems, chemicals are available to control annual grasses and broadleaf weeds in established stands of Kentucky bluegrass. (Garrison, 1960; Rampton et. al., 1971)

Chemical and mechanical roguing (hand weeding) is an effective, though labor intensive, method of weed control and is limited by the availability and skill of personnel. Since visual differences between crop and weed may only be obvious for part of the growing season, roguing practices are further limited by time and growth habits.

Important to all chemical weed control strategies is ensuring contact between chemical and weed. Burning is noted as instrumental to this potential application problem since it most effectively eliminates residues which would absorb chemicals and shield weeds from contact. Burning also kills, outright, a large percentage of shattered weed seed which, if allowed to germinate, would represent large increases in weed populations. (Lee, 1974)

Destructive insects, which can be chemically controlled, include grass mite, grass sawflies, grass mealybug, thrips, aphids, sod webworms, grass gelechiid, and grasshoppers. Billbugs, generally a problem in orchardgrass, have also been found in Kentucky bluegrass and are also controlled chemically. Control of sod webworms, gelechiid, and other pests living in the root and crown areas by chemicals is important as field burning is not a particularly effective means of control.

Wireworm, meadow plant bug, and glassy cutworm are difficult to effectively control with chemicals so that primary control of these pests is through thermal sanitation. Silvertop, when caused by these pests, will most likely be evident in Kentucky bluegrass if burning is poorly accomplished. (Cooperative Extension Services, 1981a)

The most serious bluegrass disease infestations result from ergot, smut, rusts, and powdery mildews. Though chemical control of rusts have been developed, field burning is the only economical control of the wide range of diseases and is the only control of ergot. (Hardison, 1974)

Harvest Practices

After its spring growth period, seed set, and maturing, Kentucky bluegrass may be swathed. The appropriate swathing time is judged based on experience or seed moisture content may be used effectively to determine the proper time to harvest. (Klein and Hammond, 1972.)

After swathing, seed is allowed to dry in the windrow until moisture content is fifteen percent or below to eliminate heating when placed in bulk storage. During the harvest operation, windrows are picked up by a combine in which seed is removed. Straw residue is spread on the field in preparation for burning.

Seed cleaning of bluegrass seed, of course, occurs, to some degree, in the combine. However, high quality seed must be cleaned at least by a primary and probably a secondary operation. Samples of seed are taken for certification tests (purity and germination) and bags tagged. Seed moisture must again be maintained at low levels (below ten percent) for long-term storage.

Post-Harvest Field Treatment

Presently, the most important post-harvest treatment is the burning of straw residues.

Of prime importance from an agronomic standpoint is that residue burning be accomplished soon after harvest, during the plant dormant period when green tissue is minimal. Chilcote and Youngberg (1974) and Pumphrey (1965) found minimal but negative effects on bluegrass yield due to late burning. This minimal effect is beneficial in light of smoke management programs which tend to delay burning accomplishment.

2.4 Field Burning Air Contaminant Emissions

2.4.1 Source Description

Straw and stubble residue loadings on Kentucky bluegrass and cereal fields typically fall between one and one-half and five tons per acre and under dry conditions contain between 6% and 20% moisture content (wet weight basis). However, even under very dry conditions attached stubble may exceed 30% moisture content. (Rimov,1978)

Total fuel load may drop below two ton/acre when loose straw has been removed using typical removal practices. (Miles, 1976) The remaining fuel (mostly stubble) will also have a significantly higher moisture content than the pre-removal value.

Under "good" field conditions for burning, both straw and stubble would be dry, with a combined fuel moisture less than about 20%, and with straw loosely and uniformly scattered over the stubble. Also, regrowth of green material would be minimal. Under such conditions straw obviously burns rapidly and leaves little residue. These more or less ideal, but common, conditions can result in burning rates exceeding 100 acres/hr for typical field sizes. (Larger fields usually can achieve even higher combustion rates.) Fires with these burning rates and typical geometry are not easily controlled by normally available fire suppression equipment. Once started they are practically controlled only after they have consumed nearly all the fuel within the prepared area. Because of this situation, once a field is started, a minimum time period for emissions is normally on the order of one hour.

As field fuel conditions degrade due to straw decomposition, fuel bed settling, development of green regrowth or general increase in fuel moisture content, the time required to complete the burning of a field increases. However, under these slower burning conditions, fires are more easily controlled and under suitable conditions can be extinguished.

The total emission of air pollutants, mostly fine particulate matter, can be reduced to some extent by the appropriate selection of ignition techniques. Also, certain ignition techniques can drastically affect the burning rate. Thus, the rate of particulate evolution may be modified within limits. (Miller, Thompson, Duckworth, et. al., 1976) Unfortunately, the slower burning techniques often result in a lower average plume rise with the net ground level impacts being higher. This effect is discussed more thoroughly later in this section.

Slower burn rates (area/time) and lower specific emission rates (mass of particulate/mass of fuel burned) result when a backing fire (burning into the wind) is used. Much higher acreage rates and specific emissions result when headfiring techniques are used and the fire advances with the wind. A third technique, strip-lighting, in which lines of fire are lit by advancing into the prevailing wind results in intermediate burning rates and specific emission levels. All of these burning rates may be dramatically increased by increasing the number of points of ignition or the length and number of ignition lines.

From these considerations it is clear that some adjustment of emission levels and burn rates is possible. However, precise modification and control of these factor is not feasible and extending the emission release rate to very low values is currently both impractical and beyond technological capabilities.

2.4.2 Nature of Emissions

As is typical of the combustion of most fuels containing hydrogen and carbon, the products of open field burning contain a huge variety of hydrocarbon species in addition to carbon dioxide, carbon monoxide, water and ash. The hydrocarbons have wide ranging molecular weights and upon cooling form both gases and liquids in the atmosphere. Along with suspended solids, mostly ashy materials, the liquid hydrocarbon droplets form the substantial emission of fine particulate matter typical of most open burning.

In the source sampling and analysis work that has been completed on field burns a substantial range of emission rates has been identified. (Boubel, Darley, and Schuck, 1969; Miller, et. al., 1976; Erickson and Hartford, 1979; Boubel, 1980) Table 2-V lists the important pollutants emitted by field burning and, for each, a range of values inclusive of most sampling results.

To some extent, the wide range of value for each pollutant is due to differing measurement techniques. However, wide variations are commonly noted even within the same sampling protocol and field conditions and are common to these types of field studies. From data regarding particulate matter emissions, normally the pollutant of most concern, an average emission factor of 25 lb/ton of residue would appear to be reasonable.

Field burning particulate matter is extremely fine with mass mean diameters of less than 0.1um reported from source sampling and approximately 0.25um from sampling of aged plumes. (Miller, et. al, 1976; Craig and Wolf, 1979) While this size range is consistent with other combustion sources, field burning smoke contains a high percentage of condensed hydrocarbon materials compared to

TABLE 2-V
RANGES OF SPECIFIC EMISSION RATES FOR POLLUTANTS FROM FIELD BURNING

POLLUTANT	EMISSION FACTOR lb/TON
PARTICULATE MATTER	4-100
CARBON MONOXIDE	83-139
OXIDES OF NITROGEN	1-5
SULFUR DIOXIDE	Negl.
ORGANICS	10-33

emissions from more traditional combustion sources. This hydrocarbon content of grass field smoke accounts for its odor, reactivity and, to some extent, effectiveness in reducing visibility.

Typically, it takes from 30 minutes to two hours to complete the burning of most grass seed fields. During this period the rates of emission and energy release undergo dramatic variation. Burning and emissions rates rise from zero to a peak value very early in the burn, drop or rise during the active burn period depending upon wind and atmospheric stability, drop very rapidly near the end of the active burn phase, and then remain at very low values during what may be several hours of after-smoulder.

To a large extent, the vertical distribution of the emissions in the atmosphere will be affected by the burning rates achieved, with high burn rates resulting in strong smoke column development and higher plume rise. Emissions from slow burning fires are released, in effect, at ground level and move upward mainly through turbulent diffusion only. With sufficiently active fires, however, a convective column will extend rapidly upward until it is impeded by stable layers in the atmosphere. Since there are a variety of burning rates during a given fire, emissions tend to be distributed from ground level to the upper stable layers. This upper limit typically is located from three to seven thousand feet above ground level in most areas.

The specific distributon of pollutants throughout this "mixed layer" depends upon a number of factors including the energy release rate, atmospheric stability throughout the intervening layers, ignition methods, and surface wind speeds. Under good plume rise conditions a large percentage of the total pollutants released stabilize at or near the maximum plume height with very little ground smoke. However, under poor burning conditions and high surface wind speeds all of the smoke is effectively entrained in atmospheric layers near ground level. In nearly all circumstances, smoke is dispersed eventually throughout the mixed layer downwind of the field. However, the high effective release point of the emissions under good plume rise conditions greatly lessens their effect on people since greater dispersion of pollutants occur prior to ground impact. Obviously then, vertical smoke management and most programs place great emphasis on utilizing atmospheric conditions and burning techniques that will maximize plume rise.

SECTION 3

THE NEED FOR ANNUAL BURNING OF GRASS SEED AND CEREAL GRAIN CROPS

THE NEED FOR ANNUAL BURNING OF GRASS SEED AND CEREAL GRAIN CROPS

Under present technology, the effects of pollutants from open field burning are controlled through two means: reduction of emissions or dispersion of emissions. In many areas, emission reductions mean a ban on open burning. In California and Oregon, open burning regulations require specific burning methods and compliance with other criteria in efforts to reduce overall emissions. (Oregon Environmental Quality Commission, 1978; Kinney, 1982.) However, practical methodologies for open burning, at best, can reduce emissions by about 50% and this often is accompanied by a serious increase in downwind ground level smoke impact. (Miller, Thompson, Duckworth, et.al., 1976; Craig and Wolf, 1979.) Because of the potentially significant smoke effects in some areas where it has been determined to allow burning to continue, smoke management systems are often employed to reduce the likelihood and severity of smoke intrusions. Unfortunately, smoke management program success is limited by available resources, an imperfect technology and human abilities to predict and carryout change. As a result, smoke management is less desirable from an air pollution control perspective than a practical elimination of the emissions altogether. For field burning, this means finding ways to not burn fields, and thereby, predictably and dependably reduce smoke effects.

It is recognized that each agricultural field represents a unique set of environmental, agronomic, and economic circumstances affecting its need to burn. As a result, it is believed that the degree of need to burn some fields, taking such factors into consideration, is greater than for others. If, in an effort to reduce emissions, it is anticipated that not all burning can be eliminated, it would seem most sensible to consider those reductions first that cause the least affect on farmers and provide the greatest air quality benefit. Obviously, to carry out this approach on an equitable basis, some method is required to rate the need to burn and the air quality benefit of not burning associated with each field. Since in northern Idaho a smoke management program exists which makes daily assessment of the air quality effect of burning (benefit of not burning) a given field, this report concentrates only on factors affecting the need to burn.

Though a large number of advantages have been listed as resulting from open burning, it is reasonable to summarize these in four general categories:

1. Better control of plant pests;
2. In many cool-season perennial grass plants, stimulation of yield;
3. Better control of plant competition; and
4. Lowered production costs over alternatives.

The following sections of this report discuss each of these areas as well as disadvantages of burning on farm and agricultural activity. No discussion of the effects of burning on air quality are included in this report since this problem is properly addressed through smoke management planning and rulemaking activities.

3.1 Ecological Perspective on Burning

Cool season grasses for the most part developed and evolved in the great grasslands of the world such as the Great Plains and other areas. Such areas are subject to frequent and widespread fire prior to man's control of such burning in the last century. In such an environment, fire would cause the destruction of many plants and the elimination of much plant material. In other words, plant competition and shading would be much reduced in the aftermath of fire. Since new, prime growing sites would be available, the plants which responded most quickly to establish offspring in these areas would improve their species' likelihood of survival.

Routine fire would then select plant species that would respond quickly to reproduce in the post-fire environment. For seed producing plants, this would mean rapid growth, prolific seed development, and eventual seed germination. These traits are all evident in many of the commercially important cool-season grasses used for turf and forage production.

3.2 Historical Background of Burning in Grass Seed Production

Prior to the 1940's, grass seed production in the U. S. was a largely decentralized industry, supplying grass seed as a by-product of other activities. This type of production continues in many areas of the nation particularly, Missouri and other southern states where pastures are often harvested for seed. Problems with seed quality and genetic purity plagued the seed industry making such factors as point of origin and producer reputation important in the selection of a satisfactory product. In addition to this problem, there was a need for reproduction of newly developed varieties of plants that would insure maintenance of genetic traits for which they were bred. These concerns for varietal purity were addressed through the U. S. Seed Act and corresponding state laws establishing standards for reproduction and certification of seeds.

During the 1940s, as the result of a search for a marketable crop for some 180,000 acres of poorly drained, heavy clay soils in the Willamette Valley of Oregon, annual and perennial ryegrass began to be planted in the area in large quantities. This increase in grass seed acreage formed the basis for a localized seed industry, eventually justifying specialized support industries and research activities.

However, early in its development, the ryegrass industry was plagued with grass seed and plant diseases which were not controllable through previously effective means. Breeding for disease resistance was considered impossible since there were a large number of diseases to be addressed. Also such breeding would alter varietal genetic characteristics, the maintenance of which is fundamental to seed production. Crop rotations were not possible for long-term perennial stands or on lands for which annual ryegrass was the only alternative crop. Chemical controls were not available for most diseases.

After some experimentation, researchers found the annual post-harvest burning of the grass seed residue effectively controlled most diseases of ryegrass. By 1948, open burning of seed fields had become general practice in Oregon to combat serious blind-seed disease and ergot problems. (Hardison, 1964)

Once this program of routine burning was established, the other benefits of annual burning were noted: improved control of other pests (chiefly weeds and insects), increases in seed yield, and reduced production costs. The profitability of seed production went up causing it to spread outside the wetland and steep slope habitats and displace some acreage of other crops in areas of better soil conditions. Eventually, numerous other cool-season grass species were in production in the Willamette Valley using the same post-harvest burning prescription applied to ryegrasses. Kentucky bluegrass production, being better adapted to colder winter conditions, was initiated in the Inland areas of eastern Washington, northern Idaho, and central and northeastern Oregon.

3.3 Effects of Fire on Grass Seed Production

3.3.1 Effect on Grass Diseases

As noted in the discussion above the initial purpose of burning was to control grass seed disease, particularly blind-seed disease and ergot in perennial ryegrass. Additional analysis of why burning controls grass diseases has been conducted since its use was found effective. From this work, the mechanisms for control of grass diseases may be broken down into four areas:

1. Direct destruction of fungus sclerotia residing in crop residues through incineration or extreme heating;
2. Destruction of reproduction material of many pathogens;
3. Elimination of habitat (straw and stubble residue, fall seed heads) for overwintering sclerotia; and

4. Removal of organic material (straw and stubble) that interfere with use of chemical disease controls. (Hardison, 1957 and 1974)

Because of its effectiveness in all of these areas, burning helps control most rusts and many of the numerous other leaf and stem diseases. (Hardison, 1964)

Kentucky bluegrasses are particularly susceptible to both rusts and a number of leaf and stem diseases. Also ergot has been a periodic problem in Inland production areas. On some varieties, powdery mildews have been a problem. (Fenwick, 1982) Burning of straw and stubble (or fall propane flaming of a spring seedling crop) is recommended for control of these diseases. (Cooperative Extension Services, 1981b)

Root rot diseases which have infected both cereal and Kentucky bluegrasses is not normally controlled by burning since it is largely soil-borne. However, since burning reduces the above-soil innoculum, its rate of spread and severity may be reduced by burning crop residue.

(Fenwick, 1982) Rice residues in California's Sacramento Valley are burned annually in efforts to control leaf, stem and root diseases in this crop. (Keppner, 1982) Of course, burning also reduces the substantial straw and stubble loading produced by rice.

3.3.2 Stimulation of Yield

Increases in net yield of clean seed were noticed subsequent to the initiation of a regular burning program. This increase in yield was noted when coincident control of weeds, diseases, and insect pests were not an apparent factor. Indeed, the yield stimulation effect of burning is often cited as the principal reason for burning Kentucky bluegrass. (Van Slyke, 1982; Fenwick, 1982; Ensign, 1982)

Numerous experiments were conducted by Chilcote, et. al. in an effort to identify the actual effect of burning on plant development and, in particular, seed yield. In this work measurements of environmental conditions, seed yield and seed yield components were made for a variety of post-harvest treatments. Pest problems were not a factor in the studies. (Chilcote, Youngberg, Stanwood, Kim, 1980)

Seed yields and yield components were determined for several species including Kentucky bluegrass. Data from these plot studies is shown in Table 3-I for Kentucky bluegrass only.

Compared to other grasses tested in these experiments, Kentucky bluegrass yields demonstrated medium response to open burning. In the more detailed studies of highly responsive red fescues, the increase in yield was attributed to the development of greater numbers of new tillers, axillary tillers per tiller unit, fertile tillers, and number of seeds per tiller. It is believed the greater number of young tillers with potentially more active photosynthetic material and a more prostate initial growth habit make better use of available light than unburned plants. Also by complete removal of residual straw and stubble, soil and, presumably, plant temperatures were more extreme with greater diurnal variation. Burned plants showed earlier spring panicle emergence, allowing flower development under cooler conditions which has been shown to lead to greater potential seed yields in

Table 3-I

Yield Response of Kentucky Bluegrass to Alternative Post-Harvest Treatments

	Seed Yields	Mean No. of Auxillary Tiller per Tiller Unit			Corresponding Yields (lbs/A)
		Sept.	Oct.	Nov.	
Flail Chop and Remove Straw	996	0	0	0.3	674
Burn	1,160	0.2	0.5	2.7	945

perennial ryegrass and which may be a response common to other species.

Work by Canode and Law (1977) has shown similar short-term response to burning by Kentucky bluegrass for sites in Idaho and Washington. Long-term alternative treatment studies were also part of this study, designed to determine the effect on yields of burning and non-burning post-harvest treatments. Replicated plots of several varieties of Kentucky bluegrass were established in separate locations representative of soil conditions of seed growing areas in Washington and Idaho. Post-harvest treatments included open burning, straw removal, straw and stubble removal, straw and stubble chopped and left on the field, and no post-harvest treatment. In addition, these treatments were carried out at two different row spacings.

Though not designed to assess the physiological causes of increased yield as was the work by Chilcote, et. al., similar treatments were applied to the test plots. Thus data from treated and untreated plots, which did not experience interferences from significant weed or disease infestation or other anomolies, could be used to assess the effect of yield stimulation.

As might be expected from a study involving a large number of independent variables and samples, yield results covered a wide range, making interpretation difficult. However, a few generalizations are clear. Routine open burning of residue resulted in higher yields in general and clearly provided superior long-term yield maintenance. It is also clear that no removal of straw or stubble residue normally brings on the poorest yields.

The variety of straw/stubble treatments met with mixed success compared to open burning depending upon the cultivar and, in some cases, row spacing. The effectiveness of mechanical straw and stubble removal on yield (compared with open burns) was generally better early in stand life. This is probably due to the openness of young stands which may be thinned unnecessarily by burning resulting in a net yield reduction. Yield suffered noticeably in stands not burned for several years. Also, yields on these plots did not recover fully after rejuvenation by thermal sanitation methods, though there was significant improvement. Figure 3-1, a plot of yield data ranges, shows the effectiveness of the open burning treatment in maintaining yields in old stands and the much less obvious, but still identifiable, benefit in younger stands.

High temperature exposure appeared significant to the yield attained in the following season. Low temperature treatments by open and machine burns resulted in lower yields than high temperature burns. Merion Kentucky bluegrass yields, however, were not clearly improved by the higher temperature treatments.

Other studies conducted by Chilcote and Youngberg (1975) on Merion and Newport varieties of Kentucky bluegrass (as well as other cool-season grass species) indicate at least a 25% yield reduction for continued use of non-burning post-harvest residue treatments. A 38% reduction in yield was noted for Merion if no straw or stubble was removed from plots. The prior figure compares favorably with Canode and Law (1977). In tests conducted to determine the effectiveness of field burning machines, similar yield reductions were

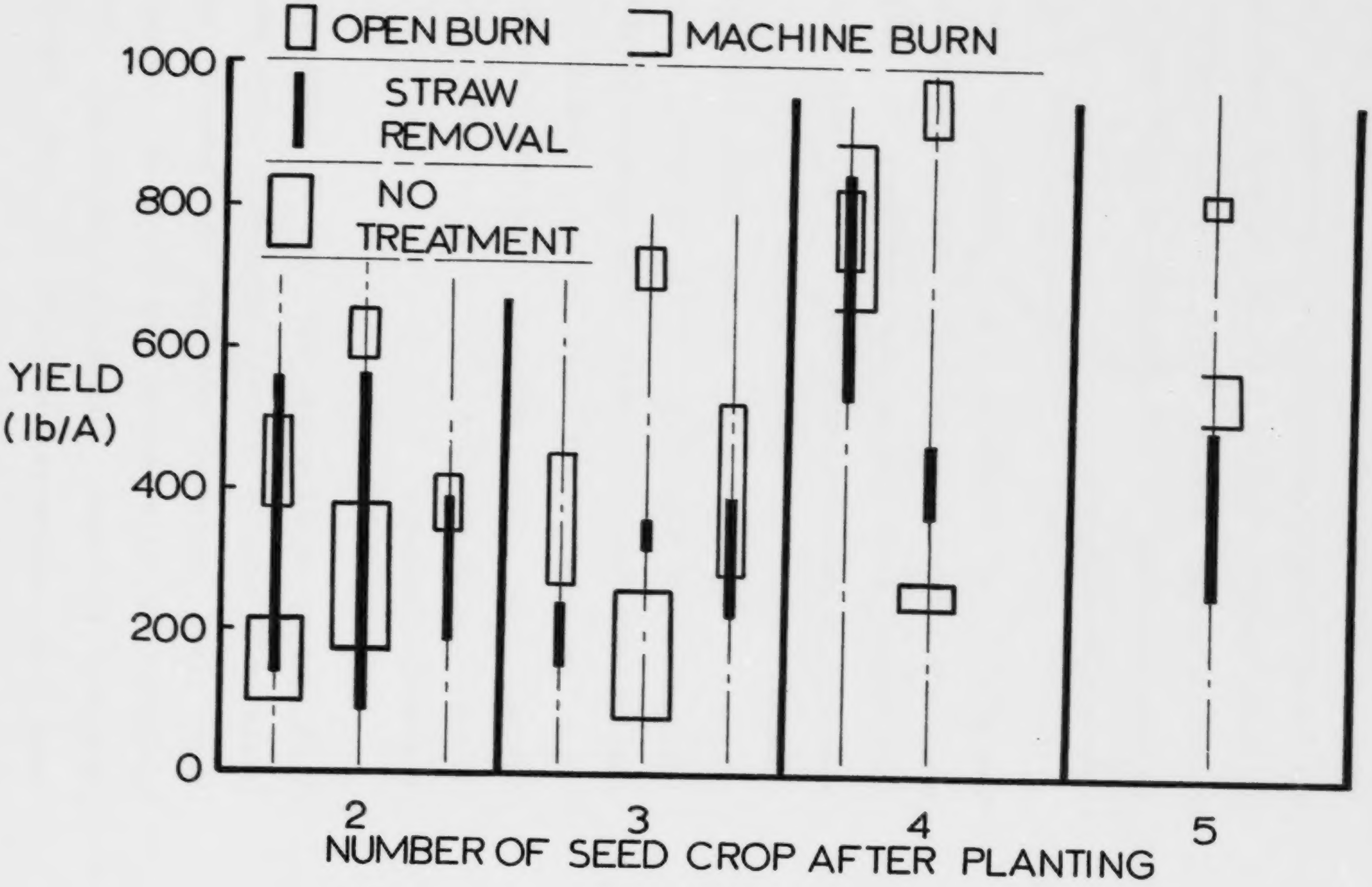

Figure 3-1 Ranges of Yield Data for Various Post-Harvest Treatments.

noted in unburned plots, though the testing period was brief. (Youngberg, Chilcote, and Kirk, 1975) In these studies, burned plots of Newport Kentucky bluegrass showed slight yield reduction compared to unburned which is in substantial contrast to Canode's results.

The effects of alternate year burning on yield have been investigated in Oregon beginning in the late 1960s. Straw removal was conducted in years when burning was not conducted. In these early studies, Merion bluegrass showed a 95% yield retention compared to annual open burning. (Chilcote and Youngberg, 1975) However, these results were based on only three years of data which, for an alternate year burning program, is minimal. In this study, mechanical removal without burning showed a 31% yield reduction for the Merion variety.

More recent studies of the use of specialized straw and stubble removal equipment have shown good yield retention compared to annual open burning for fine fescue and Kentucky bluegrass species. (Chilcote, Youngberg, and Young, 1981) Some yield increases, compared to open burning, were noted in the young stands of these species where straw and chaff were collected from the combine rather than spread on the field. These results parallel some observations by Canode on Kentucky bluegrass. The specialized "crew-cutter" equipment used in the Oregon studies is designed to close cut stubble left by normal straw removal and "vacuum" the loose residue and seed on the ground. Normal operation rate has been less than two acres per hour.

In association with the above "crew-cut" studies, a program analyzing the effects of less-than-annual burning was initiated. These studies also were designed to assess the effects on yield and production costs of a program involving combined burning and non-burning post-harvest treatment. After four years of data collection, control plots which have been continuously crew-cut show poorest yields and seed quality. In addition, crew-cutting in non-burning years has shown superior to less effective straw and stubble removal methods. Alternate year burning in general has shown good yield retention compared to annual open burning. Though only two cycles have been completed, yields in a well-established Newport Kentucky bluegrass stand are comparable to routinely burned plots. Similar results were found with fine fescue, but yield reduction of approximately 15% per year were noted in a turf-type perennial ryegrass. (Chilcote, 1982)

In summary, grass seed yield studies applicable to the Pacific Northwest have shown that long-term yield reductions in Kentucky bluegrasses are to be expected if post-harvest burning is not used. Yield reduction effects seem to be least noticeable in young stands but become greater with time. Table 3-II summarizes yield reduction data for various varieties and post-harvest treatment compared to the open burned control plots in each of the studies. As may be seen by this data, a program of alternate year burning coupled with off-year straw and stubble removal, appears to provide reasonable yield maintainence for at least five years, the length of studies conducted to date. In saying this, it should be reiterated that these studies did not provide for the analysis of the effects of disease and insect infestation. Only the Oregon crew-cutter studies address and attempt to quantify specific weed

Table 3-II

Average Yields of Kentucky Bluegrass Cultivars for Various Post-Harvest Residue Treatments Expressed as Percentages of Average Yields Resulting from Comparable Annual Open Burning

Variety	Experimentor	Reported Study Period	Type of Post-Harvest Treatment	Percentage of Comparable Open Burn Average Yield
Merion	OSU	1972-1973	None	76.8%
Newport	OSU	1973-1974	None	109.1%
Merion	OSU	1970-1971	None	40.0%
		1972-1973	None	77.0%
Merion	OSU	3 year period		69.0%
Merion	OSU	Alternative year burn with SSR		95.0%
Merion	OSU	4 year period	SSR	75.0%
			SR	73.0%
			None	62.0%
Garfield	WSU	4 crop period	SR	51.0%
			None	30.0%
Merion	WSU	3 crop period	SSR	85.0%
			SR	72.5%
Fylking	WSU	average of 5th and 6th crops only	SSR	61.0%
			SR	33.0%
Merion	WSU	4 crops	SR	87.0%
			SSR	104.0%

SR - Straw removed; SSR - Straw and stubble removed; None - no residue removal.

infestations. Thus, the effects of not burning on these problems is very imperfectly known, except that certain diseases can thrive and spread rapidly in the absence of burning. (Hardison, 1964)

3.3.3 Effects of Burning on Competitive Plants

3.3.3.1 Control of Weeds and Weed Seed

Control of weeds in the field is particularly important in grass seed production. Weed infestations, when of sufficient magnitude, can cause:

1. Direct loss of seed production through competition for light and nutrients;
2. Loss of seed quality, resulting in possible loss of certification and a lower price;
3. Loss of seed production due to clean out of saleable crop seed when attempting to remove unwanted weed seed;
4. Loss of seed marketability due to abundance of noxious weed seed;
5. Extensive additional production costs to control weeds including application of additional chemicals and flaming, premature

crop rotation, extended fallow periods, and extraordinary establishment costs; and

6. Loss of potential grazing and straw sales income due to noxious weeds in the field or application of chemicals potentially poisonous to livestock.

Control of weeds in perennial seed fields is normally accomplished through establishment of a weed-free stand (normally aided by chemical weedicides), routine burning, and chemical roguing (hand weeding) of the field. In almost all studies of Kentucky bluegrass mechanical removal of thatch and disturbance of the soil has shown yield reductions in the following year arguing against the use of cultivation for weed control. (Rampton, et.al., 1971; Canode, 1972; and Canode, 1977)

Routine field burning has been shown very effective in maintaining a clean field. Burning is credited with destroying in excess of 95% of the live weed seed on the soil surface. (Lee, 1974) In addition, it kills many annual and perennial weeds. Of course, burning is not effective on perennial grassy weeds which must be removed chemically or mechanically. In these circumstances, removal of crop residue is important to visually identifying non-crop varieties and insure proper contact between chemicals and the plant to be controlled.

3.3.3.2 Effect on Shattered Seed

Like most grasses, Kentucky bluegrass is subject to extreme crop loss due to seedhead shatter as the crop approaches maturity. Though steps are taken to minimize this problem, anywhere from ten to fifty percent of available seed has been lost in the harvesting process. Much of this seed falls back on the field. If allowed to germinate, the field would be over populated which normally results in a net yield reduction. However, more importantly, from the standpoint of certification, seed from these new plants can not be certified. In sufficient quantity, such seed could cause loss of certification for the entire crop. As with weed seed, open burning destroys a very high percentage of these shattered crop seeds. (Lee, 1974)

3.3.4 Effect on Insects and Other Pests

Grass seed crops in the Pacific Northwest are affected by more than a dozen major pest groups. Methods of attack of these pests are varied but may be dichotomized into those that attack the leaf and stems and those that feed in the crown and root area. Some pests, such as the billbug, feed in both areas in the course of their life cycle. (Kamm and Robinson, 1976)

Life cycle habits, of course, determine to a large extent, the method of and ability to control these pests. For burning to be effective, the pest must be vulnerable to the fire during the summer burning season. Aphids, thrips, meadow plant bugs, and other stem and leaf feeders are in this circumstance, and their populations are dramatically reduced by burning. However, billbugs, sod webworms, and grass gellechiids feed on roots during this period and are all but immune to the effects of burning. (Kamm, 1982; Holman, 1982) Since pests that attack the leaf and stem are considered relatively minor problems in the Inland bluegrass areas, open field burning plays a relatively minor role in direct control of pests. However, its effectiveness in removing post-harvest residue is important to pest control. (Cooperative Extension Services, 1981a; Kamm, 1982) Residues tend to absorb and de-activate pesticides directed toward crown and root dwelling pests. After removal of this straw residue by burning or mechanical means and subsequent dissipation of the residual charcoal, chemical controls can better penetrate to underground larvae.

Table 3-III summarizes the role of open field burning in controlling pests in the Inland area. As may be seen, those pests which are of most significance are not controlled effectively by burning and require applications of chemicals. Burning is not mandated for the control of these crown and root dwellers except to the extent that it is the most economical method to remove straw and stubble prior to chemical application. Burning is very effective in controlling (not eliminating) stem dwelling thrips and aphids. These, however, are not considered a major problem in the Inland area and are subject to control by chemicals. (Holman, 1982)

Table 3-III

Control of Grass Seed Pests by Open Field Burning

Kentucky Bluegrass Pest	Level of Seriousness of Pest to Inland Kentucky Bluegrass Production	Effectiveness of Burning as a Control	Alternative Control Method	Comments
Sod Webworm	Moderate	None	Chemical	Removal of straw and stubble aids in application of chemical to affected areas.
Grass Gellechiid	Moderate	None	Chemical	Same as above.
Billbug	None	None	Chemical	Normally limited to orchardgrass and mature bluegrass.
Aphids	Minor	High	Chemical	
Thrips	Minor	Very High	Chemical	
Meadow Plant Bug	Minor	Very High	Chemical	Time of appearance of meadow plant bug near maturity makes effective application of chemicals difficult

3.4 Economic Advantages and Disadvantages of Burning

The use of open field burning as a cultural tool affects farm income both through its direct effect on production costs and its somewhat less direct effect on seed prices and marketability. Since grass seed production (and much of farming in general) is a low margin enterprise, both of these areas can grossly influence net returns. Since the effects of burning on seed production are broad, a discussion is provided in the following section of the specific areas where field burning plays a major role in influencing the cost and price of grass seed. The following is not intended to be a comprehensive economic analysis of Inland Kentucky bluegrass and cereal farming; however, it is intended to provide substantiated information on the economic impact of field burning on these enterprises.

3.4.1 Effect of Burning on Production Costs

Production costs include all costs associated with in-field activities such as tilling, seeding, application of chemicals, harvesting, and burning, as well as associated materials and equipment costs. In the case of Kentucky bluegrass, production costs include the expenses of establishment and eventual tear-out, both of which are exceptional compared to cereal production costs.

3.4.1.1 Tilling Costs

Tilling costs are largely affected by soil type, final seed bed preparation needs, weed control needs, and straw incorporation needs. For Kentucky bluegrass production, all tilling is limited to the years of establishment and removal; cultivation in between having been shown detrimental to seed yields. Alternatively, cereal grains require, under typical cultural practices, annual field preparation involving some level of tilling activity. In general, reducing overall tilling results in at least short-term cost reductions leading to improved profitability.

Burning most directly effects tilling costs in two ways: straw incorporation costs and the ability to conduct certain no-till or minimum-tillage practices. Since cereal and other annual crop fields are normally cultivated each year, the effects of burning on plowing costs are especially important to the production expenses of these crops. The remaining discussion will be limited to straw and stubble management of cereal crops as affected by the use of burning.

Typically, there is some three to five tons of stubble and straw residue per acre after harvest of wheat. Similar amounts will be found for most annual grass seed and other cereal crops. To incorporate this amount of material into the soil so that a suitable seed bed may be prepared, normally would require several operations. Depending on location, residue may be chopped and then plowed or disked. Secondary harrowing operations prepare the seedbed for drilling. In extremely heavy stubble (irrigated) conditions, additional disking or chopping may be required to expedite straw decomposition and provide a suitable seedbed. Heavy residue commonly cannot be decomposed within the available time if insufficient moisture or oxygen slow the soil biological activity. Plowing in heavy residue situations is further complicated by the tendency for straw to "plug" plows, requiring interruption of the operation while the mold board plow or disk is cleared.

The time required for ground preparation activities in general can be reduced by reducing or eliminating the amount of residue. Under most near-term considerations, burning provides the most cost effective method for the farmer to eliminate this material.

As was noted, soil plays a significant role in the cost of seedbed preparation. Soils with high per acre energy requirements, slow straw decomposition, or soils which cause abnormally high equipment wear increase seedbed preparation costs, and therefore, accentuate the short-term economic benefits of residue removal through burning. This circumstance exists on the Rathdrum Prairie where soil stone content commonly exceeds 50% and plowing costs are high due to excessive wear. In Garrison soils common there, plowshare life has been noted at about ten acres (equivalent to plowing roughly 300,000 lineal feet). (Van Slyke, 1982; Carlson, 1982) This high rock content limits residue treatment options for similar reasons. Flail chopping or rotovating of residues which have been demonstrated to improve decomposition (Burkhardt, Keppner, and Miller, 1975) are limited by the equipment wear and cost associated with the operation. (Van Slyke, 1982) Absent these treatments, decomposition of the heavy residues of the irrigated Prairie is slow.

The slow decomposition rates for grass sod and cereal stubble and straw on the Prairie have been noted by several sources. (Van Slyke, 1982; Ensign, 1982; Carlson, 1982; McDole, 1982; and Morrison, 1982) Low moisture retention (soils on the Rathdrum Prairie are noted as well-drained to excessively-drained (Weisel, 1981), low microbial activity, and low soil temperature (both presumably due to the high rock content) have all been suggested as reasons for the slow decomposition rates, but none have been singled out as key.

Though burning of cereal residue, rather than its incorporation, nets direct short-term reductions in production costs, there are also costs attributable to this practice. These costs are both immediate and long-term in nature. Upon burning, much of the nutrient value of straw is lost. Routine burning also results in general loss of soil organic matter along with a corresponding loss of tilth and water-holding capacity.

Though not of particular importance on the Rathdrum Prairie, burning has been associated with much increased erosion in hilly areas. On annually cropped cereal fields, soil losses on burned fields were noted as two to four times the soil loss on fields where straw and stubble were incorporated. (Engle, 1976) Except for the need to maintain overall farm profitability burning of cereal crop residues is not recommended because of the long-term adverse effects on farm land. (Van Slyke, 1982; Ensign, 1982; and Morrison, 1982; Peterson, 1982)

3.4.1.2 Fertilizer and Chemical Use

Fertilizer needs are determined by evaluation of soil condition, crop needs, and residue management decisions. Of particular importance is the maintenance of adequate nitrogen levels to avoid nitrogen deficiency in the crop when changes in residue management occur. Normally, increases in decomposing crop residues require the addition of fertilizer nitrogen to avoid a deficiency in the crop. Nitrogen added for this purpose is not lost but is "tied-up" and not available to the crop until it is recycled at the end of the decomposition process.

Initiating the incorporation of heavy loadings of organic material with inadequate native nitrogen after a period of routine burning of post-harvest residues, therefore, requires additional nitrogen. A twenty-five to forty percent increase in nitrogen may be needed depending upon residue loading. Since fertilizer applications represent approximately ten to fifteen percent of production costs, a substantial increase in fertilizer needs may alter short-term profitability. Several years of residue incorporation (with additional fertilizer) eventually results in a stabilized nitrogen picture with net nitrogen release offsetting that which is required by the annual mass of residue. Once this equilibrium is established, increased nitrogen, over crop needs, is only required in those field areas of unusually high residue loading. (Engle and Halvorson, 1978)

Though it would require a short-term increase in nitrogen fertilizer, a cessation of burning would result in retention of other nutrient materials lost as a result of burning. Thus in the long-term analysis, a reduction in fertilizer needs results when burning is eliminated. In particular nitrogen, sulfur, and phosphorus compounds, which tend to be lost in various volatilized products of combustion, are retained if straw is incorporated. (Engle, 1976)

Of course, important non-volatile minerals and trace elements contained in residues are returned to the soil upon burning of the materials, making them immediately available to a subsequent crop. If straw is incorporated, they would become available as the straw decomposes.

As has been noted, chemicals are routinely applied to both grass seed and cereal grain fields for control of weeds, diseases, and other pests. Open burning tends to reduce the need for the amount of spraying through several mechanisms, some of which have been discussed previously:

1. Outright destruction of a large percentage of undesirable organisms through incineration;
2. Elimination of straw and stubble as a medium or habitat for reproduction and growth; and
3. Elimination of material that interferes with application of chemical controls to infested areas.

Though it is clear that burning greatly aids a chemical application program, the exact benefit is difficult to quantify since there is significant variability in the levels of disease, animal pest, and weed problem. Even with a good combined burn and spray program, serious disease outbreak is noted. The extent of insect and related pest problems are highly influenced by severity of winter weather and the effect of favorable environmental conditions can greatly overpower what are normally very effective chemical control measures. (Kamm, 1982; Holman, 1982; and Ensign, 1982)

The removal of the straw and stubble is critical to efficient, if not always effective, application of chemicals. Heavy residues can absorb or block large amounts of applied chemical. Since most modern chemicals have a limited residual potency once applied, direct or immediate contact with the organism to be controlled is essential for effectiveness. (Kamm, 1982) To the extent straw and stubble residues remain exposed on the soil surface, spray application program effectiveness is proportionately reduced. Depending upon chemical costs and economic conditions, such increased residue would be expected to result in the increased use of chemical controls (heavier or more applications); however, because of the widespread use of burning little information exists to quantify the level of increase.

3.4.1.3 Straw Removal and Marketing

Essentially, all non-burning alternative treatments of perennial grass seed require the removal of at least the loose straw. (Miles, 1976) Similarly, the difficulties of plowing heavy cereal straw loads could be addressed through removal of straw and/or stubble. Obviously, straw removal would then be a critical production activity in the absence of annual open burning. The cost of straw removal and the value of the collected material would be important aspects of overall production costs.

Historically, demand for straw from cereal grain and grass seed production has been low while potential supply has been high. A conservative estimate of straw available from seed and grain production in the Pacific Northwest would exceed twelve million tons annually or about fifty bales for every person living in the area.[1] As a result of the limited market, mostly for livestock bedding and minor amounts for feed, few serious efforts have been made at large-scale straw collection. Integrated, "whole-harvest" concepts, where crop and residue are collected together, have been tried recently only on an experimental basis. Efficient collection and handling systems for hay and forage have been developed, and are in use, but the low market value of straw has not stimulated the use of such systems for its collection. As a result, most grass and cereal straw are collected and removed using standard balers and bale handling equipment.

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[1] Based upon data of Boyle, Oliveira, and Whittaker, 1982.

Though it is recognized that standard baling is not the most efficient method for removing and transporting straw, it does leave straw in what is perhaps its most marketable form. Methods of bulk removal resulting in large straw packages requiring machine handling severely limit potential users. Such methods really require the establishment of producer-consumer agreements that would support specialized straw marketing and handling systems. (Miles, 1976) This, of course, assumes consumers of significant quantities of straw in these forms exist.

Without changes in straw use patterns, no significant market for straw removed from Kentucky bluegrass and cereal fields can be assumed, requiring the farmer to underwrite the costs of straw removal and disposal. (Wells, Currie, Mazzucchi, and Eakins, 1979) Table 3-IV shows the relative cost of this activity with other production costs.

3.4.1.4 Effect of Loss of Field Certification

In the absence of burning, increases in weeds and non-crop plants can normally be anticipated. Also, off-generation plants would be anticipated, though perhaps not detectable, in an old stand. A higher probability of disease infestation would be anticipated too.

In severe cases, such problems can result in a loss of field certification leading to lower crop sale prices and, depending on contracted commitments, possible tearout. Such premature rotation requires the original establishment

Table 3-IV

Ranges of Selected Kentucky Bluegrass Farming Costs (Powell, 1983)

Cost Category	Cost Ranges ($/Acre)
Preharvest costs	
Fertilizing	60-102
Pesticide	31
Bags, tags, etc.	40-58
Irrigation	57-72
Interest on Operating Capital	10-15
Harvest Costs	
Swathing	8-9.50
Combining	97-127
Transportation and Miscellaneous	5-6.50
Post-Harvest Costs	
Open Field Burning	2.50-3.00
Straw Removal (custom)	38-62
Stubble removal	23.00
Other Fixed Costs	
Amortized Establishment (7year rotation)	35-53
Land	20-50
Overhead	7.10
Management	10-14

costs to be amortized over a shorter time period than a field in which certified seed production was maintained. The net effect of the shortened rotation is an increased cost burden on each crop year and a reduced profit over the life of the stand. Again, Table 3-IV provides a comparison of amortized establishment costs compared to annual costs for Kentucky bluegrass seed production.

3.4.2 Effect of Burning on Crop-Related Income

Income from crops sold is influenced by yield and eventual unit selling price. Price is in turn a function of the quality of the grain or seed crop. The yield and quality of annually cropped grains are much less influenced by burning than are the yield and quality of the perennial Kentucky bluegrass crops.

As noted in section 3.3.2, yield tends to decline with time after the first or second seed crop if Kentucky bluegrass is not burned. An equilibrium yield level of approximately 40% of the yield of annually burned field is indicated in the complete absence of burning. For any given seed price, this of course represent a 60% decrease in income. Alternative post-harvest treatments and rotation periods can both raise this equilibrium level and retard the rate of yield decline with concommitant increases in production costs.

Similar declines in yields have been noted in other cool-season grasses, though the eventual equilibrium yield and rate of decline varies dramatically among species and varieties. As an example, "Merion-type" Kentucky bluegrass tends to maintain yields better absent burning than do some coarser varieties.

Losses in seed quality have also been noted to occur from reduced field burning. Normally, this is due to increases in the percentage of weed seed and sometimes due to increases in the quantities of diseased seed. Such losses are not well documented in most studies because, most often, determining basic yield values have been the goal of research and because it is normally possible to clean seed sufficiently to allow it to be certified. However, the cleaning process causes some good seed to be lost; effectively reducing yields. Thus, there is an inter-relationship between seed quality and net yield. Research results are quoted typically on the basis of "clean seed" which takes into account yields, quality, and processing factors.

3.4.3 General Effect of Burning on Public Costs

Public costs may be separated into two areas: direct operational expenses such as those associated with the operation of a regulatory program, and costs associiated with public exposure to resulting air contaminants. This latter category includes costs related to personal health effects, property damage and cleanup, loss of trade, property loss due to escaped fire, and visibility-related delays or accidents. As noted earlier, these public exposure costs are diverse and difficult to assess especially if aesthetic and other subjective factors are included. Also as noted reductions in field burning emissions (acreage not burned) is deemed a satisfactory surrogate for assessing the relative change in public exposure effects as results from alternative burning programs. Thus improvements in these exposure-related problems are assumed to be proportional to reductions in burning and are quantified here on that basis.

Direct public costs are associated with planning and implementing regulatory activities to limit smoke impact. These activities include special studies of alternative control methods, operational smoke management, enforcement of regulations, development of regulations and associated research and public participation efforts. The costs of these activities vary according to the overall program size and levels of effort aimed at smoke control program improvement. Improvement efforts in turn are stimulated by existing air pollution levels and public interest.

It would not be anticipated that alternative post-harvest treatments would significantly affect the size or complexity of the smoke management operational program except when a significant reduction (say greater than 50%) in annual burning is contemplated. Much of the expense of smoke management is related to data collection and interpretation which are largely fixed costs. The greatest cost savings are effected by shortening of the season, arbitrary reductions in service (hours per day, days per week, etc.) and service area, or a substantial reduction in allowed burning.

Enforcement costs vary according to methods of restricting burning. Enforcement of burning authorized through a smoke manager is relatively straightforward with overall costs proportional to seasonal burning activity and level of desired enforcement. Enforcement of limitations on acreage burned requires extensive tracking of individual burning activity and the costs associated with this effort would be in addition to costs of enforcing daily management program directives.

Planning, regulation development, and research costs are extremely variable since they are scaled often to meet anticipated rather than current needs. Fortunately, selection of any particular alternative post-harvest treatment considered in this report would not effect significantly these costs except if the selection subsequently proves to be inadequate or otherwise inappropriate or requires parallel research. Consequently, planning, regulation development, and research costs remain relatively independent of the specification of individual control program elements. However, a need for substantial efforts in these areas should be expected as long as smoke control efforts do not satisfy public concerns.

Some of the public cost of open burning can be ameliorated through reducing the effects of smoke by emission reduction or smoke management. Costs would be expected to change linearly with emission reduction. However, beneficial effects due to emission reductions or modifications in smoke management procedure probably could be assessed only through monitoring air quality, public satisfaction, cumulative personal health costs or other factor relatable to the public costs.

Public costs may be also be offset through a fee or tax program based upon emissions, cost of regulation, planning and research costs or other criteria. Such fees are collected in the Pacific Northwest states and California. However, only in Oregon is the fee designed to cover all direct costs of operation and research. Of the $3.50 per acre fee in Oregon, 45% is dedicated to research with the remainder going to smoke management, enforcement, and program administration. (Oregon Department of Environmental Quality, 1982)

SECTION 4

EVALUATING POST-HARVEST TREATMENT ALTERNATIVES

4. EVALUATING POST-HARVEST TREATMENT ALTERNATIVES

The basis for rating and eventually selecting any alternative program for control of a source such as field burning must consider a variety of elements important to the public; regulatory officials; and seed producers, processors, and consumers. Little can be expected in terms of a long term solution to this issue, if the interests of these groups are not recognized and addressed in considering alternatives.

The consideration of these diverse interests requires the assessment of a range of air quality impacts as well as regulatory and enforcement requirements. The extent to which a proposed control effort needs to address each of these areas as well as the effects on farm crops and costs is largely a matter of individual interests and investments. Since only one such plan can be used, some equitable process must be employed to assess and weigh the effect of any proposed plan on interested parties and the general public. Normally this is a laborious process involving assembly and evaluation of information, development of tentative pllans, and plan review by affected groups, elected officials or their representatives, and the public. Alternatives to burning in northern Idaho, if any, will be subject to similar processes. It is hoped the background information in this report and the subsequent ratings of alternative burn programs will serve as a useful starting point for subsequent public decision-making.

4.1 Control Program Objectives

As a first step in rating a potential control program, program objectives must be identified and classified as to their significance. Some program objectives are of such importance that the effort would be meaningless or impossible if they are not met. Following the terminology of Kepner and Tregoe (1965), these required components are "MUSTS." Less critical elements of an alternative are those which are not necessary to basic function but are important to improved operation or conservation of labor and financial resources. These less critical objectives are termed "WANTS." A preliminary identification of MUST and WANT objectives assists in elimination of the poor or unuseable alternatives.

Table 4-I lists MUST and WANT objectives for alternative field burning control programs. Additional MUST and WANT criteria may be added for specific issues but the listed categories were designed to address the northern Idaho situation. MUSTS were based upon the need to make some net improvement in smoke effects in the area and the expressed opinion by parties on both sides of the issue that seed producers should remain in business. The two year time stipulation establishes the urgency of the current need and would eliminate, of course, any alternative with a very long lead time.

The WANT objectives were established based on a previous analysis of northern Idaho field burning issues (Freeburn, 1982) and a review of other desireable traits of control programs. The WANT list was compiled to insure that all major issues and needs would be addressed but with each WANT being relatively independent of one another. (Inclusion of additional WANT objectives that are really only a subset of another general WANT can unfairly bias subsequent analysis toward alternatives that best satisfy that general WANT criterion.) Because the approach results in generalized categories, a brief listing of the factors included in each category is also given in the table.

The relative importance of each WANT objective must be considered when assessing a given program alternative. Those programs which better fulfill important WANT objectives are more valuable than those which only address successfully the less significant objectives. Based on a paired comparison analysis (see Appendix), the WANT objectives of Table 4-I have been prioritized according to importance. A weighting value, indicating relative importance, is included in the table after each WANT objective.

Because of the evident importance of the net effects on air quality (WANTS 1. and 3.) and the costs of making improvements in air quality (WANT 2.), these factors are the subject of detailed analysis in a subsequent section of this report. The remaining WANT objectives are discussed below.

4.1.1 Minimize Changes in Farm Management Needs

Any significant change from present grass seed and cereal cultural practices will require the farmer to adjust his farm management practices to meet those new requirements. Perhaps of most concern would be new farm operations requiring major investments in additional equipment or additional time and labor requirements of the busy harvest and post-harvest period. Major concerns would be

Table 4-I

Objectives for Proposed Field Burning Control Programs

MUSTS

The program must:

- Result in a net reduction in smoke effects
- Have no significant effect on farm solvency
- Be implementable within two years

WANTS

The program should:

1. Minimize the net exposure of people to smoke (requiring considerations of net population exposure levels on an annual, daily, and hourly basis; peak concentration levels; total dosage; and methods to determine and track such information) [11];
2. Minimize net costs to growers and the public (requiring consideration of all factors affecting net return to the grower (i.e., yield, seed price, production costs) and costs of regulation and enforcement) [10];
3. Minimize adverse aesthetic effects (requiring consideration of general and local visibility reductions, plume blight, loss of scenic vistas with special consideration given to high use periods and recreational areas) [5];
4. Minimize changes in farm management needs (requiring consideration of additional time, equipment, and labor need of alternative post-harvest treatments, smoke management constraints, or alternative farm enterprises) [4];
5. Minimize season length and uncertain scheduling of burning (requiring consideration of methods of compressing burning activity, eliminating early and late season burning, and standardizing daily, weekly, and annual burning periods) [1];
6. Make pollution control costs comparable to other sources (requiring consideration of net pollution control costs for similar source circumstances) [1].

post harvest operations such as straw and stubble removal or machine burning with inherently low acreage rates. Such operations require significant time for completion whether the work is actually done by the farmer or on a custom basis. Subsequent operations such as fall fertilizing then also would be delayed. Also, unless these operations are performed on the more expensive custom basis, such additional cultural activities could delay fall preparations for other unrelated crops. Similar delays can be induced through more restrictive smoke management alternatives.

When alternative treatment procedures are selected which severely limit burning, seed producers may elect to grow an alternative crop such as peas, lentils, corn, or alfalfa. Such forced selection of alternative crops requiring a major change away from a farmer's traditional practices would be expected to result in a net reduction in productivity in the period of transition. The additional costs due to these losses in productivity and new equipment purchases necessary to grow and harvest alternative crops are not included in the subsequent cost analyses in this report.

4.1.2 Minimize the season length and the uncertainty in the scheduling of burning

Because crop growth, harvest and burning activities are all weather dependent, there is considerable variability in the date of the start of burning, daily burning levels, and the date of completion of burning. This variability, combined with the impracticality of disseminating continuous, accurate information regarding routine smoke management decisions have left the public and business community with no way to predict or plan regarding the smoke effects of burning. These smoke effects are of particular concern to those involved in recreational activities or who suffer adverse health effects. As a consequence their has been substantial public support for firm limits on the times of burning activity. Especially desirable to recreational businesses is a shortening of the burning season to define and minimize that portion of the summer recreation season affected by field burning smoke.

Though alterations to the timing of burning are mainly concerns of operational smoke managers, decisions regarding the amount and types of crops to be burned can also affect season length. A general reduction in burning could allow earlier completion provided: (1) growers continue to match current daily burn rates; and (2) current late season burning is due to smoke management concerns rather than field availability. Whether a shorter season results from a reduction in burning will depend on operational smoke management priorities since an argument can be made for maintaining season length and reducing daily burn totals in order to reduce short-term smoke concentrations.

Wheat crops generally are harvested after Kentucky bluegrass seed crops. Also winter wheat is not seeded until late summer or early fall. This schedule coupled with the lower priority for burning wheat stubble (compared to grass) results in wheat residues being burned, in general, later than grass seed residues. Restrictions on burning wheat residues would tend to reduce late season burning preferentially and thus could be used, without other major smoke management restrictions, to shorten the season.

4.1.3 Make Pollution Control Costs Comparable To Similar Sources

Programs for controlling the emissions of open burning pollutants exist in all Pacific Northwest states as well as many states in the Southeastern U. S. and California. Cost for these operations are borne by both landowners and regulatory agencies. Direct costs of smoke management programs are the most readily determined cost of pollution control since they are often supported by permit or production fees. However, in some cases,costs are obscured in an agency's overall operating costs and management expenses.

Another cost related to most control programs is due to lost opportunity. Both smoke management programs and alternative post-harvest treatment require the dedication of additional time to post-harvest activities. In some instances such additional activities result in delays that prevent desired crop or treatment options from being implemented. These costs generally have not been addressed in previous estimates of control programs since they would be based largely on gross assumptions, if not speculation. For these same reasons, estimates of these costs are not included in this report.

Costs of alternative, non-burning post-harvest treatments should be included in pollution control costs. These in general, are much larger than smoke management expenses even if associated research and permitting fees are included in the latter. As a result costs of smoke control alternatives that include emission reductions through reduced burning would be expected to be substantially higher than upgraded smoke management strategies. For example, in Oregon, burning fees are the highest of all programs investigated at about $3.80 per acre burned. However, this amount represents only about one seventh the cost of the least expensive reduced-burning alternatives discussed in subsequent sections.

4.2 Cost Factors Relative To Post-Harvest Treatment Alternatives

As may be seen from Section 3, burning of grass seed and cereal grain fields affects potential production of crop and production costs in a variety of ways. Because the specific effects of burning, or lack of it, (such as yield reduction, additional farming operations, altered rotation schemes) are so varied, it is difficult to compare one effect with another and make inferences about their relative importance to the crop, the farmer, air quality, or other relevant variables.

Fortunately, numerous economic analyses of farm operations have been completed providing detailed cost information on most farm activities. Such cost data allow the various farm functions to be compared to each other, as well as to the income provided by the crop in question, alternative crops, and alternative crop expenses. In most states, farm enterprise data sheets are routinely updated, providing reasonably current estimates of these farm costs. Numerous grass seed enterprises have been so detailed. Similar data, based on special economic studies, are available for Kentucky bluegrass seed production in eastern Washington. (Burt and Wirth, 1976 and 1979)

Using these economic data, it is possible to evaluate, on a common basis, a variety of the effects of lessened burning. The net effect of handling increased residue, applying additional chemicals, and absorbing yield reductions are then comparable in terms significant to farm operations.

Though the economic impacts of air pollution have been estimated in various studies, such an undertaking is well beyond the scope of this report. Rather than develop an economic impact model specific to the northern Idaho situation, overall field burning emissions is proposed as a measure of air quality effects due to field burning. A further simplification equates acreage to emissions, thus making the acreage burned an indicator of air quality impacts. Estimated reductions in acreage burned then may be used as the estimator of improvements in field burning-related air quality effects for comparison with related additional costs. The worth of a proposed alternative then may be represented as the net emission reduction per additional dollar of cost, or:

$$\frac{\text{Reductions in emissions}}{\text{Increased costs to producers}} = \frac{\text{Reduction in acres burned}}{\text{Increased costs to producers}}$$

The assumption of emissions as an indicator of air quality effects is valid when area-wide impacts are averaged over many seasons with random variations in field and weather conditions and smoke management effectiveness. Because of the variability of these factors, it is well understood that acreage burned may not reflect impacts in the short-term, especially in some selected locations. In addition, some specific effects of field burning, such as the length of the burning season or the number of smoky days in a season which may be important to those affected, are not necessarily directly relatable to reduced emissions. However, the correlation between emissions and these factors is believed to be positive and to support the use of the "acreage burned" statistic as the simplest and most practical indicator of the overall air quality effects of field burning.

4.2.1 Analysis of the Costs of Not Burning

As noted in the background sections of this report, burning of both Kentucky bluegrass and cereal grain residues are conducted in areas of northern Idaho with Kentucky bluegrass concentrated in Kootenai and Benewah counties. Soil conditions, terrain, and rainfall vary dramatically between the Rathdrum Prairie seed growing areas and other areas of this region. These varied conditions require somewhat different cultural practices and cropping patterns to be used depending upon location. Accordingly, production costs are distributed differently among farm operations with some higher than others. In particular, large cost items, such as land, irrigation, and establishment expenses, can vary significantly due to location, farm history, and growers' decisions. However, these decisions are made to maintain profitability, which is closely tied to yields. As a consequence, yield values vary remarkably little with no consistent gradient across the area. Yield can vary significantly, however, depending on the specific variety (cultivar) selected by the grower.

To avoid dealing with the wider variation which would result from assessing the total farm operation, the analysis used in this report addresses only the incremental costs and benefits (reductions in emissions) that result from alternative post-harvest treatments. Using this approach, significant and highly variable expenses such as land cost, fixed cost due to capital investment, and the cost of other farm management decisions are not included which, leaves a clearer picture of the cost/benefit relationship and range of options for a reduction in field burning. The resulting analysis, though not descriptive of any particular farm circumstance, is more uniformly applicable to all farms with a grass seed or cereal enterprise.

An incremental cost approach results in a much simplified analysis of the cost of those factors affected by burning. This is because, for major categories of farms, incremental costs tend to be very similar. In this analysis, the following categories were found useful and representative of a significant portion of the acreage subject to burning in northern Idaho:

1. Common Kentucky bluegrass grown for seed under dryland conditions;
2. Proprietary Kentucky bluegrass grown for seed on irrigated, gravelly soils;
3. Cereal crops grown on irrigated gravelly soils; and
4. Cereal crops grown on non-gravelly soils under dryland conditions.

Further subdivision beyond these four catagories gave no further insight into the cost analysis. For each of the assumed circumstances identified by the categories above, a number of post-harvest treatment options are available to the farmer.

These include, for Kentucky bluegrass, open burning, various forms of removal of straw and/or stubble, or no post-harvest treatment. For cereal crops, similar options are available, though all are followed by some level of cultivation. Alternating or rotating these post-harvest treatments may also be assumed.

Table 4-II displays the assumed soil/crop circumstances and several post-harvest treatment options for cereal and Kentucky bluegrass crops burned in northern Idaho. Supplemental information regarding the cost derivations of Table 4-II are included in the Appendix.

Since the annual post-harvest burning of fields has been selected over time, due largely to its cost effectiveness, it is logical to expect additional net costs to be incurred, either through increased production costs or decreased revenues from seed sales (reduced yield of clean seed) when burning is reduced. Evaluation of literature referenced in Section 3 of this report supports inclusion of a number of cost categories that may potentially affect net returns. These cost categories are also listed in Table 4-II. Obviously, with a number of cost category activities affected by burning, the seed producer may select any of perhaps one hundred alternative treatment programs with costs varying accordingly. Which program is selected would depend upon observed field conditions, availability of resources, and probability of success. In a newly established stand with no special weed or disease problems, the additional costs of not burning may be limited to straw removal expenses and anticipated yield reductions. On the other hand, an established stand suffering from clear weed and pest problems may require extensive straw and stubble removal, additional chemical applications, and extraordinary seed cleaning to obtain a readily marketable product. This considerable variability in needs results in a range of potential costs for each cost category, keeping in mind that these are additional costs related to reduced burning. From these values, an estimated average expected cost has been determined for inclusion in Table 4-II. These cost estimates are based upon assumptions discussed in subsequent sections and detailed in the Appendix.

4.2.1.1 Post-Harvest Residue Treatments

Table 4-II

Estimated Additional Production Costs and Yield Reductions Due to Reduced Burning

Field/Crop Type Treatment	Number of Crops	Additional Costs, Average Annual per Acre				Amort. Est. Cost @ 12%	Machine Burn	Total Addition Product Costs	Average Clean Seed Yield Reduct (%)	Net Loss
		Straw/Stubble Removal and Disposal	Incorp./ Cultivate	Weed Control	Pest/Disease Control					
Merion Kentucky Bluegrass-Gravelly Soil										
1. Biennial Burn	5									
SR		25		7.50	15.00	14.70		62.20	10	
SSR		37		7.50	15.00	14.70		74.20	10	
None		0		11.25	15.00	14.70		40.95	25*	
2. No Burn	4									
SR		50		7.50	30.00	27.75		115.25	20	
SSR		74		7.50	30.00	27.75		139.25	20*	
None		0		15.00	30.00	27.75		72.75	38	
3. Burn 2 of 3 Years	6									
SR		17		7.50	10.00	7.00		41.50	6	59
SSR		25		7.50	10.00	7.00		49.50	6	65
None		0		11.25	10.00	7.00		28.25	12*	69
Newport Kentucky Bluegrass-Other Soils										
1. Biennial Burn	5									
SR		25		7.50	15.00	13.40		60.90	18	
SSR		37		7.50	15.00	13.40		72.90	18	
None		0		11.25	15.00	13.40		39.65	30*	
2. No Burn	4									
SR		50		7.50	30.00	25.30		112.80	27	
SSR		74		7.50	30.00	25.30		136.80	22	
None		0		15.00	30.00	25.30		70.30	52	
3. Burn 2 of 3 Years										
SR		17		7.50	10.00	6.00		40.50	8	
SSR		25		7.50	10.00	6.00		48.50	8	
None		0		11.25	10.00	6.00		27.25	12	
Annual Open Burn	7	0		0	0	0	0	0	0	
Annual Machine Burn	7	50		0	0	0	71	121.00	0	

Table 4-II

Estimated Additional Production Costs and Yield Reductions Due to Reduced Burning

Field/Crop Type Treatment	Number of Crops	Additional Costs, Average Annual per Acre				Amort. Est. Cost @ 12%	Machine Burn	Total Addition Product Costs	Average Clean Seed Yield Reduct (%)	Net Loss
		Straw/Stubble Removal and Disposal	Incorp./ Cultivate	Weed Control	Pest/Disease Control					
Fylking Kentucky Bluegrass-Gravelly Soil										
1. Biennial Burn	5									
SR		25		7.50	15	14.70		62.20	27	
SSR		37		7.50	15	14.70		74.20	20*	
None		0		11.25	15	14.70		40.95	36*	
2. No Burn	4									
SR		50		7.50	30	27.75		115.25	48	
SSR		74		7.50	30	27.75		139.25	28	
None		0		15.00	30	27.75		72.75	52*	
3. Burn 2 of 3 Years	6									
SR		17		7.50	10	7.00		41.50	15	
SSR		25		7.50	10	7.00		49.50	10	
None		0		11.25	10	7.00		28.25	17*	
Cereal Grain-Gravelly Soil										
1. Biennial Burn	1									
SR		28	9.00	2.00	0	0		39.00		
None		0	17.75	3.00	0			20.75		
2. No Burn	1									
SR		56	18.00	7.50	0			81.50		
None		0	35.50	7.50	0			43.00		
Cereal Grain-Other Soil										
1. Biennial Burn	1									
SR		28	5.80	2.00	0			35.80		
None		0	11.90	3.00	0			14.90		
2. No Burn	1									
SR		56	11.60	7.50	0	0		75.10		
None		0	23.80	7.50	0			31.30		
Annual Open Burn	1	0	0	0	0	0	0	0		

*These yield reduction percentages were estimated based on available related research data.

4.2.1.1 Post-harvest residue treatments used in determining the expected costs of not burning included those used in research efforts in Washington and Oregon, and are reflective of the practices likely to be substituted by seed producers. They also reflect the likely result of the application of regulations designed to reduce burning emission; that is, the prohibition of the burning of at least some acreage in each year. As a result, proposed alternative treatments include: no burning; burning on alternate years; and burning two years out of three. A baseline of essentially zero additional costs also is provided for the annual burning alternative.

Since post-harvest straw removal activities are a very significant factor in simulating open burning effects and also greatly influence the effectiveness of applied chemicals, they were selected as additional criteria for subdividing post-harvest alternatives. Post-harvest straw removal methods include two approaches expected to be used should burning restrictions be placed in effect: removal of straw only; and removal of straw and stubble. Baling of straw (standard bales) is assumed. Removal of stubble is anticipated to be accomplished through close clipping or chopping followed by removal or no further treatment. Since straw removal is costly, the "no removal" options is included since it may be the most or only feasible alternative under some circumstances.

Two other alternative treatments should also be discussed briefly as they have been the subject of discussion and research efforts. These are burning by use of a mobile field sanitizer or field burning machine and burning partial residue loadings. Mobile field burners have been and are under continuing development in various locations where open field burning restrictions have been threatened. To date, overall cost and poor reliability have severely limited their application, though agronomic results have generally been good. Also, based upon experiences in Oregon, machine burning did not appear a viable option because of the additional time required by the machines to accomplish sanitation. Under the best circumstances, Oregon experts anticipated machine use to be limited to the highest priced, proprietary varieties of seed. As a result of these expectations and what would be a slow growth in the population of such units, they are not considered as a viable alternative treatment in this analysis, though costs are included for comparison purposes.

Burning only the stubble after removal of straw could result in a substantial reduction in emissions, perhaps as much as forty percent. (Miller, et. al., 1976, Erickson, et. al, 1979) However, removal of straw fuel also results in two deleterious effects. First, the santizing effects of burning are reduced as ground temperatures are reduced due to the lessened fuel load and greater number of "skips" under open field burn conditions. (Canode, 1977) Second, the reduced energy released during combustion results in a reduced plume rise and increased amounts of low elevation smoke. As a result, downwind, ground-level smoke concentration at locations downwind are greater per pound of emission than under conditions where a full fuel load is burned. Again, Oregon studies have shown low elevation emissions from modified back fire burns (with energy release rates similar to those by reduced fuel loads) to have a much greater impact on downwind air quality than a full fuel load burned under conventional conditions. (Craig and Wolf, 1979) For this reason, partial straw removal followed by burning is not recommended as a post-harvest treatment option.

Based upon the research and expertise cited in Section 3, a more rapid deterioration of grass seed field cleanliness, as indicated by weed and non-crop populations and incidence of disease, may be expected when burning is not conducted annually. As a result, the profitable life of a bluegrass stand is shortened, requiring the stand's removal and replacement by a different crop. Therefore, the anticipated stand life is less for a field that receives no burning than those that receive burning.

Stand life is important in farm and crop economics since substantial costs are incurred in establishing a perennial bluegrass field. These initial fixed costs may be assessed on an annual basis if they are amortized over the life of the stand and offset by the annual revenue derived from crop sales. Obviously, the magnitude of these annualized costs is directly tied to stand life and can noticeably affect annual net returns.

Stand life estimates have been made for each category of burning activity noted in Table 4-II. The estimates are based upon the success of researchers at maintaining viable stands without burning. Most of this research has been limited to six years or less and data on consistent non-burning treatments for more than five years are extremely limited. Thus, stand life estimates are in some cases extrapolations of available experimental results. Since burning has been ubiquitous in Pacific Northwest seed production areas, these experimental results are the best information available on the effects of reduced burning on shortening stand life.

4.2.1.2 Other Crop Treatments and Bases for Costs

As noted earlier in this section, the cost analysis for assessing the need to burn is based on additional incremental costs associated with production activities and yield losses. This section reviews the bases of these additional assigned costs and the reason(s) for their inclusion in the analysis.

The costs noted below are presented independently of one another and this is something of an oversimplification in the analysis. Treatments such as straw removal effect subsequent chemical treatments and seed cleaning expenses. Where possible, a general relationship was assumed based on research and the comments of experts. However, it is realized that such generalizations are just that and will not apply in all cases. Routine applications of pesticide under unfavorable conditions may simply not provide the control normally achieved resulting in measurable clean seed yield loss. Alternatively, in some circumstances, leaving stubble in place may have no apparent effect of the following yield. It is clear from experimental work that great variability in results should be expected.

4.2.1.2.1 Straw Removal and Disposal

Straw removal costs may be based on the use of bulk removal systems. These normally result in the lowest per acre cost for removal. These systems also produce straw in a large bale or stack with their attendent handling and resale problems. Using these systems, removal of straw to field side on a custom basis is costed at $20 to $35 per acre. (Miles, 1976; Kropf, 1983) If straw is removed in the somewhat more marketable standard bale form, removal costs increase to $37 to $62 per acre. However, since custom straw removal normally would be by standard baling, this cost is used for analysis purposes.

Disposal of straw will, of course, depend upon its marketability. However, as noted previously only a small percentage of the available straw can be expected to be sold before the market is over-supplied. Thus, most seed producers would need to dispose of straw by other means. Straw may be burned in clean stacks with a reduction in visible emissions. (Miles, 1976) Data on the total emissions of this approach are not known, but are expected to be less than for burning the distributed straw.

Disposal of the straw through normal or accelerated decomposition could also be undertaken for straw not disposed of for other purposes. If straw is to be disposed of at field side, approximately one to two percent of the available acreage would need to be devoted to this purpose. If straw is to be disposed of at other nearby sites, loading, shipping, and unloading cost need to be included. Based on studies by Wirth, et. al. (1977) and inflation in the intervening period, baled straw removal, loading, and trucking to a nearby location would cost $49 per acre. This compares favorably with similarly escalated costs developed by Miles. (1976)

Custom raking, baling, and stacking rates are quoted as $45 to $60 per acre depending upon straw loading (Kropf, 1983; Ringsdorf, 1983) Significant hauling distances would increase these costs.

4.2.1.2.2 Incorporation of Residue

The economic benefit of burning with regard to incorporation is due to the reduction in solid matter that must be processed and mixed with soil to allow preparation of a seed bed. Because burning eliminates approximately 70% of the above ground dry matter (90% for cereal crops), plowing, disking, and related operations are much reduced.

"No-till" methods of seeding are under very active investigation and are in use on cereal crops in areas wih moderate to light straw loadings. Data on cost effectiveness of no-till methods is not available for gravelly soils and heavier straw loads common to the Rathdrum Prairie. Consequently, cost estimates for this method on cereal or direct seeding of annual crops into herbicide-treated, established Kentucky bluegrass stands is not available. The latter technique is in use on the Rathdrum Prairie and there is concern that without burning chemical effectiveness would be much reduced due to residual straw. This circumstance is comparable to other chemical application without straw and stubble removal.

Tillage costs represent only a small part of the overall costs of a stand of Kentucky bluegrass, especially if it is maintained for seven or more years, as is now common. Virtually all tillage costs are encumbered during the establishment year. Traditional economic analyses then amoritize this cost over the life of the stand. Thus, the major impact of higher tillage costs is shown in the amortized establishment costs of Table 4-II for Kentucky bluegrass. Incorporation costs for cereal crops are shown as annual costs.

Costs of residue incorporation are based on cultural practice costs (Oregon State University, Department of Agriculture and Resource Economics, 1975 and 1979; Powell, Lindeborg, and McIntosh, 1980; and Powell, 1983) and actual operations conducted by grass seed and cereal producers. (Van Slyke, 1982; Carlson, 1982) For most areas, cost estimates collected by university economics researchers are adequate. However, application of these estimates to the Rathdrum Prairie would not reflect the higher costs of cultivation in this area. Investigation of increased plow wear due to the high stone content of soils of the areas lead to additional costs of incorporation that are significantly higher than those in other soil conditions. Additional costs were based on the processes identified in Appendix Table A3-I being used in each case.

4.2.1.2.3 Weed, Disease and Pest Control

Reduced burned is anticipated to result in increased incidence of pest problems serious enough to warrant additional treatment. For many seed producers, routine burning constitutes their weed, disease, and other pest control program. It is not uncommon for no chemical controls to be used. (Van Slyke, 1982; Holman, 1982; Peterson, 1983)

With reduced burning, it is anticipated that chemical treatments will need to be applied to grass seed fields at least in years when burning is not conducted. Further, the number of applications required for control is assumed to be related to the level of residue removal. With reduced burning one additional application of weedicide is assumed in all years. Hand roguing is assumed in years when burning is not conducted. Without straw removal, one additional application of weed sprays is anticipated in non-burn years and higher spray concentrations are assumed in the complete absence of burning. As noted in previous sections, these activities and costs are in addition to the present control program.

For disease control cost estimates, it was assumed 25% of the acreage not burned would be treated. The amount of acreage to be treated each year increases for consecutive years without burning-the no burn option. The amount of acreage treated would increase each year by 25% of the total acreage so that in a four-year, no burn rotation, 75% of the acreage would be treated prior to the last harvest.

Of course, the need for such treatments is highly variable depending upon annual weather, cleanliness of fields at establishment, and nearby sources of weed seed; disease innoculum; etc. Also, the benefit of a chemical application over a load of straw residue may not be considered worth the effort by some producers since much of the chemical will be absorbed by that material. Recommended upper limits on the number of applications of certain stem and leaf disease controls may also limit the application of additional chemicals to below the amounts anticipated in developing the costs of Table 4-II.

4.2.1.2.4 Amortized Establishment Costs

As noted earlier, experimental results indicate reduced burning would lead to a shorter rotation cycle to maintain yield (income) than is possible with annual burning. Under this circumstance, the costs of establishing and removing the stand of Kentucky bluegrass will need to be amortized over this shorter stand life. The annualized costs, of course, will increase roughly in inverse proportion to the reduction in stand life.

Establishment costs for Kentucky bluegrass are similar throughout the northern Idaho/eastern Washington grass seed producing areas, except where soil conditions require special fertilizer, irrigation, and seed bed preparation practices. Of these, only the significantly more expensive tillage costs and irrigation, due to gravelly soil, can be separated into a meaningful subcategory.

Establishment costs for the Rathdrum Prairie (and other gravelly soil areas) are based upon economic analyses provided by Powell (1983).

4.2.1.2.5 Seed Cleaning

Increased incidence of weeds and diseased seed in crop seed may be adequately removed by additional cleaning operations. However, associated with these additional cleaning operations would be some clean seed loss. Experience indicates this loss to be about 15 to 30 percent for each cleaning. The cost of cleaning is normally assessed by weight, on a weight-in and weight-out basis, making per acreage costs dependent upon yield and harvest procedures, and therefore, highly variable. Costs due to seed loss through clean-out are more evenly distributed; however, as lower yielding varieties normally demand higher prices per pound and vice versa.

Additional cleaning requirements would be affected by the type of treatment applied to the field. Loss of burning and lack of straw removal would be assumed to result in greater recleaning requirements over the life of the stand. Applications of chemicals would also affect seed loss during cleaning and the amount of cleaning required. These assumptions are based upon results of experiments in Oregon (Chilcote, et. al., 1981) and Washington (Canode and Law, 1977), but actual recleaning requirements would be anticipated to be extremely variable. For example, of particular expense would be crop seed containing noxious weed seeds, such as quackgrass, that are of a size and shape similar to the Kentucky bluegrass variety being cleaned. Several operations may be necessary to clean such a seed lot. Alternatively, a heavy infestation of a large seeded weed may reduce yields through competition, but its seed would be easily removed from the crop seed.

Experimentation with non-burn alternatives in Oregon have generally indicated that existing weed problems would be difficult to control without the use of burning, while a "clean" field may have a reasonable chance of remaining so without burning given proper chemical controls. Because of the extreme variability demonstrated in cleaning requirements, and because of the important role of residue removal and chemical controls in providing clean seed, estimating an appropriate cost for this production element is extremely difficult. As a result, specific costs for additional cleaning are not included. For the purposes of this analyses, the cost of maintaining clean seed (including additional cleaning costs) will be considered to accrue to the assumed straw removal and additional chemical application programs.

4.2.1.3 Clean Seed Yield Loss

Reductions in clean seed yield represent lost revenue to seed producers. Based on the alternative treatment scenarios presented here and historical prices, yield losses attributable to reduced burning would be the largest single factor affecting profitability. On this same basis, dollar losses associated with yield reductions often will be larger than the total of all increased production costs.

Because both yield and seed prices can vary dramatically from year to year, revenue losses due to yield reduction cannot be reliably forecast. Therefore, it is more useful to simply estimate yield losses as a percentage of expected yield under check conditions, normally that of annual open burning. This is the approach taken by most researchers in reporting yield effects of post-harvest treatments.

Table 4-II identifies the average percentage yield reductions that may be anticipated through application of the listed post-harvest treatments. The values are based upon research, involving Kentucky bluegrass cultivars, aimed at the question of the effects of post-harvest treatments. This includes the work of primarily Canode, Law, et. al. (1972) in eastern Washington and northern Idaho; Chilcote, Youngberg, et. al. (1975) in Oregon; Nordestgaard, et. al. (1976) in Denmark; and Elling (1982) in Minnesota. The yield reductions listed in Table 4-II are based upon the assumed crop rotation period also listed and the year-by-year yield reductions available in the literature. (Wirth, et. al., 1977; Canode and Law, 1977) The method is illustrated in the Appendix. As a result, average yield reductions listed here may be somewhat less than those based upon longer rotations. Based on these data and Table 4-II, Figure 4-1 illustrates the general effect of reduced burning on additional production costs and yield.

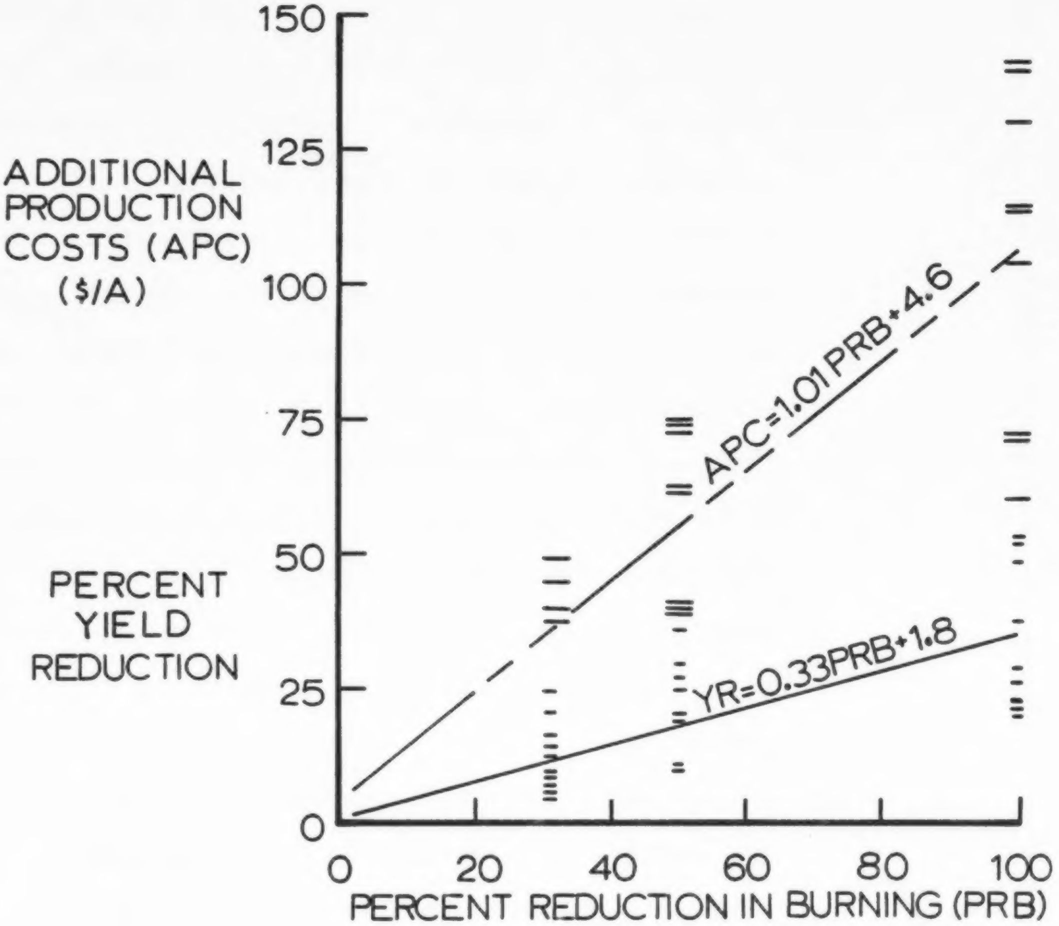

Figure 4-1 Additional Production Costs and Yield Reductions for Various Percent Reductions in Burning.

4.3 Required Increases in Seed Prices to Offset Additional Costs of Reduced Burning

The combination of increased production costs and reduced yields which would be anticipated as a result of reduced post-harvest burning could be offset with a sufficient increase in seed prices. Further, seed price increases could restore net returns to levels equivalent to those achieved under an annual burning program. It is possible to calculate the needed price increases if one makes use of current production costs and utilizes the incremental cost data of Table 4-II.

Calculations were conducted to determine the increases in seed prices required to maintain net returns equivalent to those possible under an annual open burning program. Similar analyses could be completed using other criteria such as maintenance of return on investment; however, net return (profit) is probably most clearly understood and will identify the trend of price requirements.

Equating net return levels for annual burning and various alternative burning programs, using procedures outlined in the Appendix, allows the calculation of the required increase in price for the given crop. Since existing prices determine the level of present profits, the required price increase is a function of prices under annual burning circumstances. Figures 4-2 through 4-5 illustrate the effect of reduced burning on the required crop prices to maintain the identified relationship between net profits under annual and reduced burning circumstances. Net return levels, expressed as a percentage of the annual burning net return, are included to address:

1. The potential for assessing an additional cost for control of air pollution; and

2. The increasing or decreasing cost of living.

As may be seen from these figures, in order to maintain net returns near current levels, dramatic increases in crop prices would have to occur. Required seed prices are well beyond the historical price of Kentucky bluegrass seed of the last few seasons.

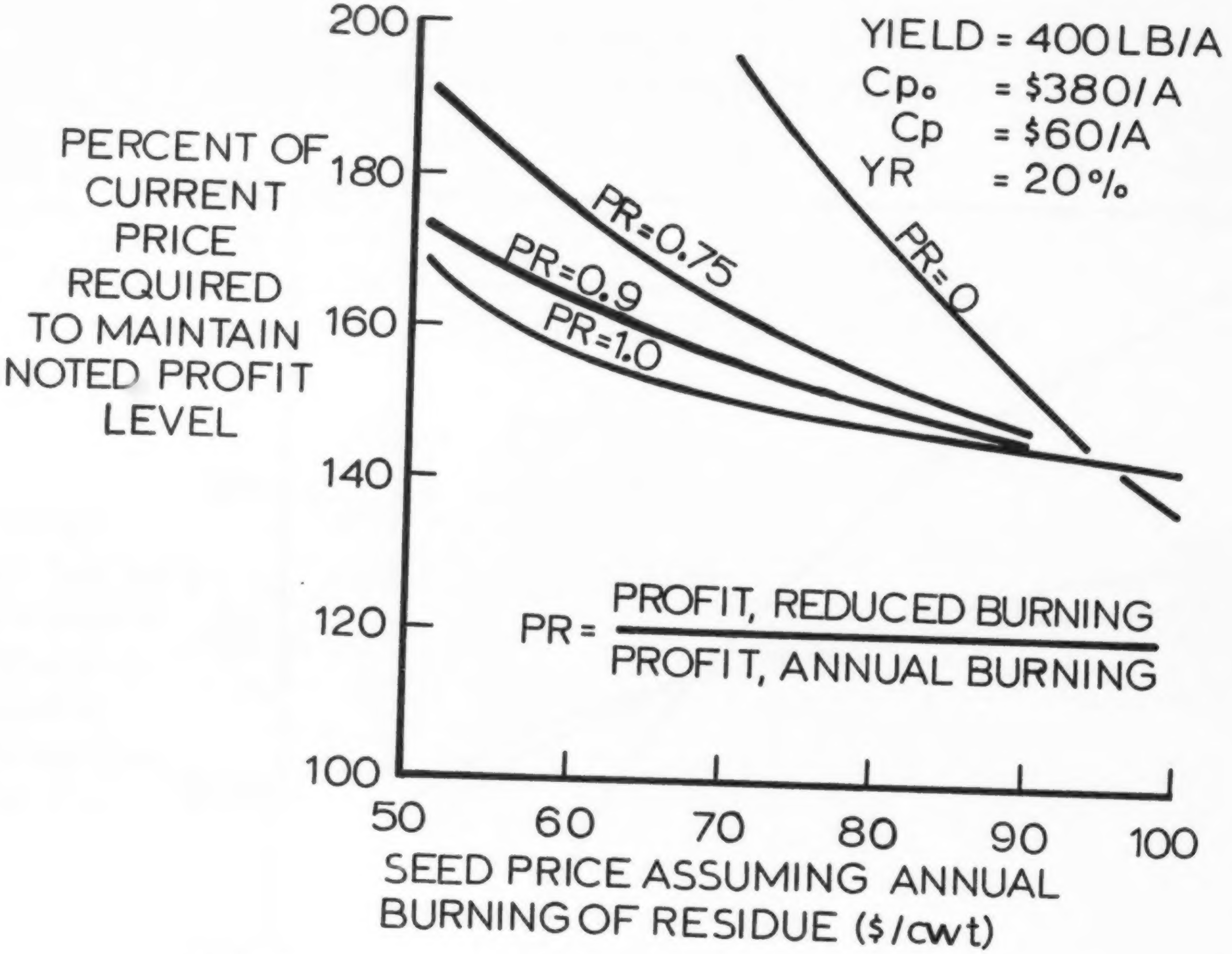

Figure 4-2 Percentage Price Increase Required to Maintain Noted Profit (Net Return) Levels for Kentucky Bluegrass.

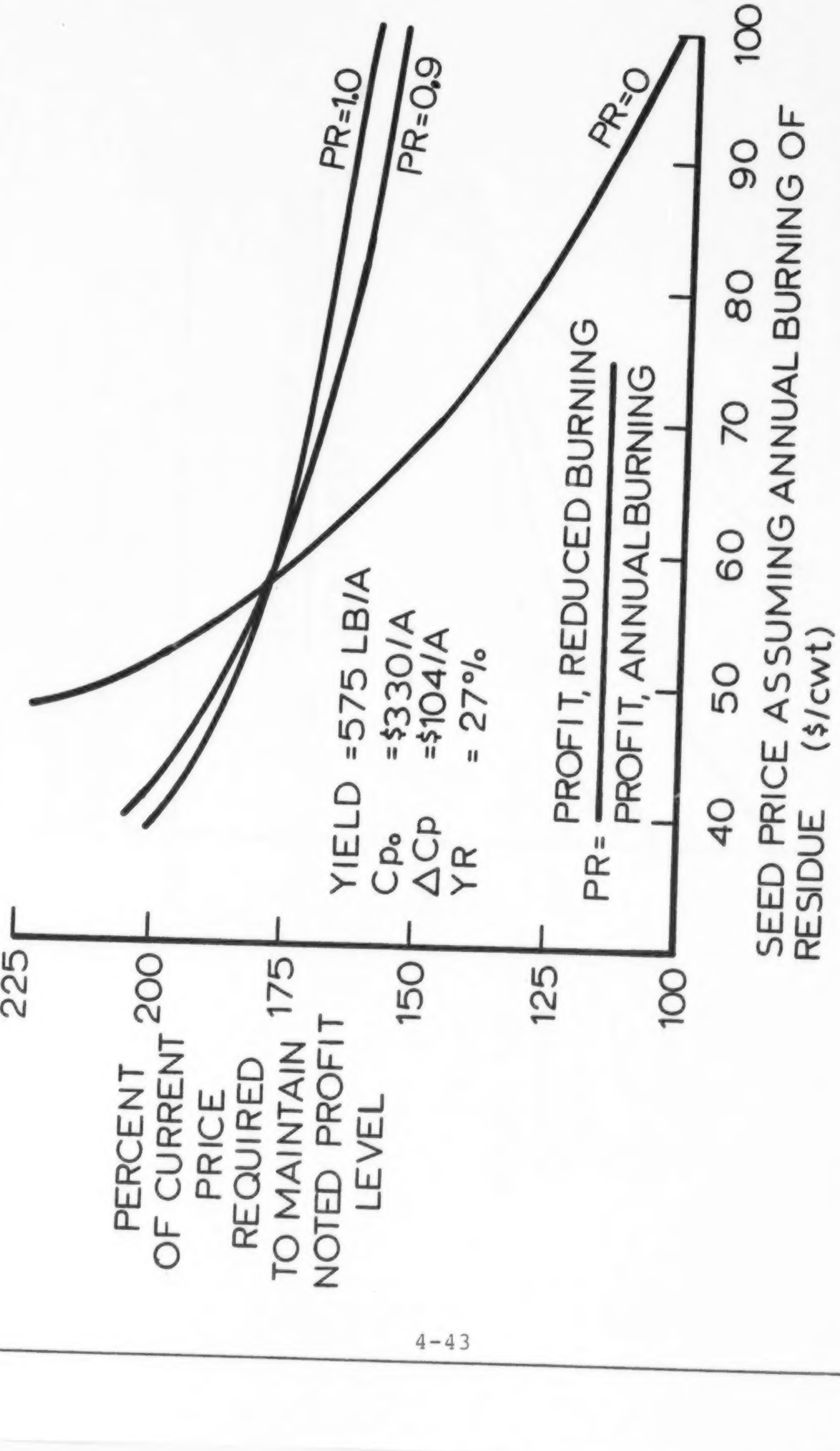

Figure 4-3 Percentage Price Increase Required to Maintain Noted Profit (Net Return) Levels for Kentucky Bluegrass.

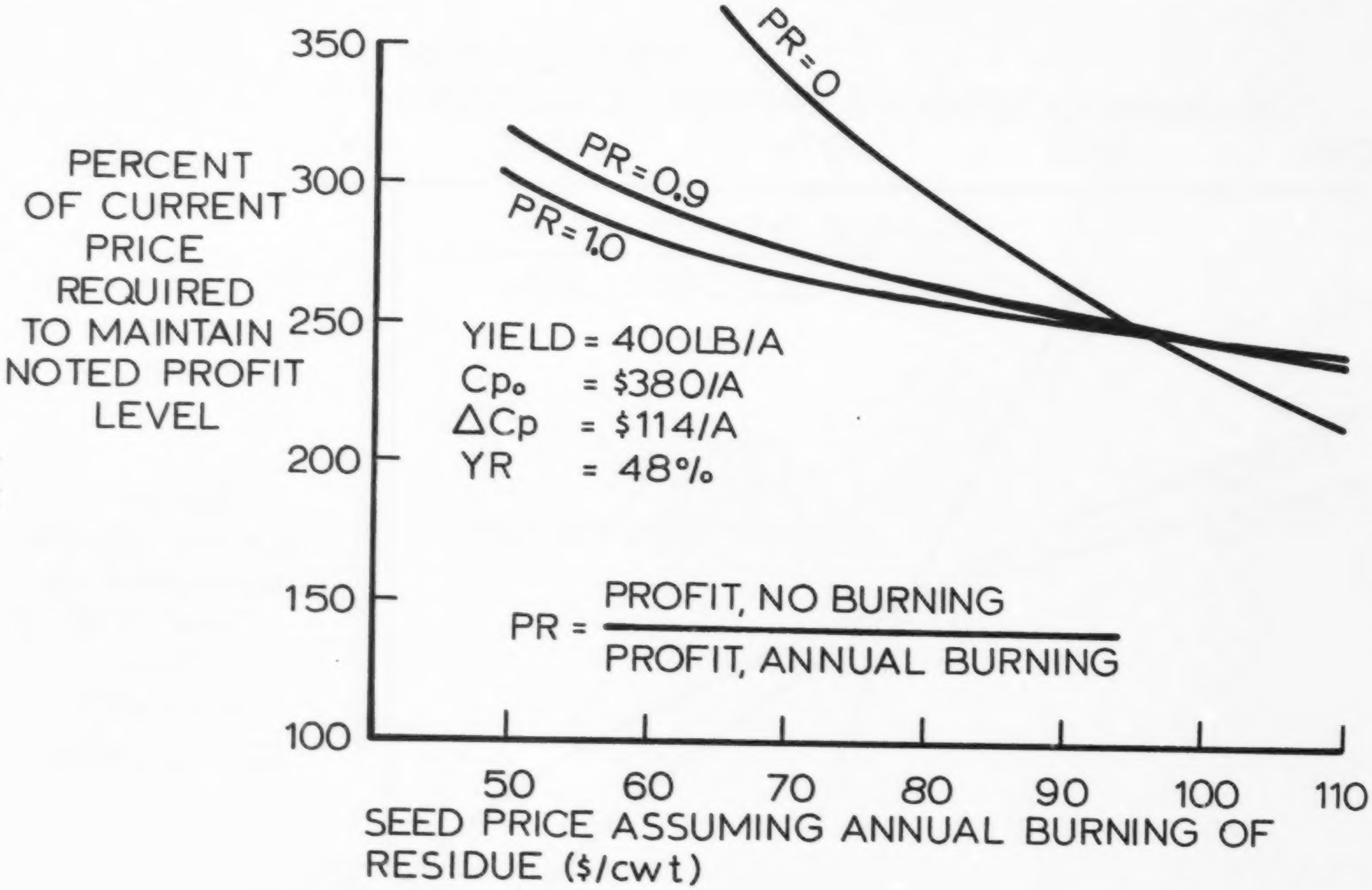

Figure 4-4 Percentage Price Increase Required to Maintain Noted Profit (Net Return) Levels for Kentucky Bluegrass.

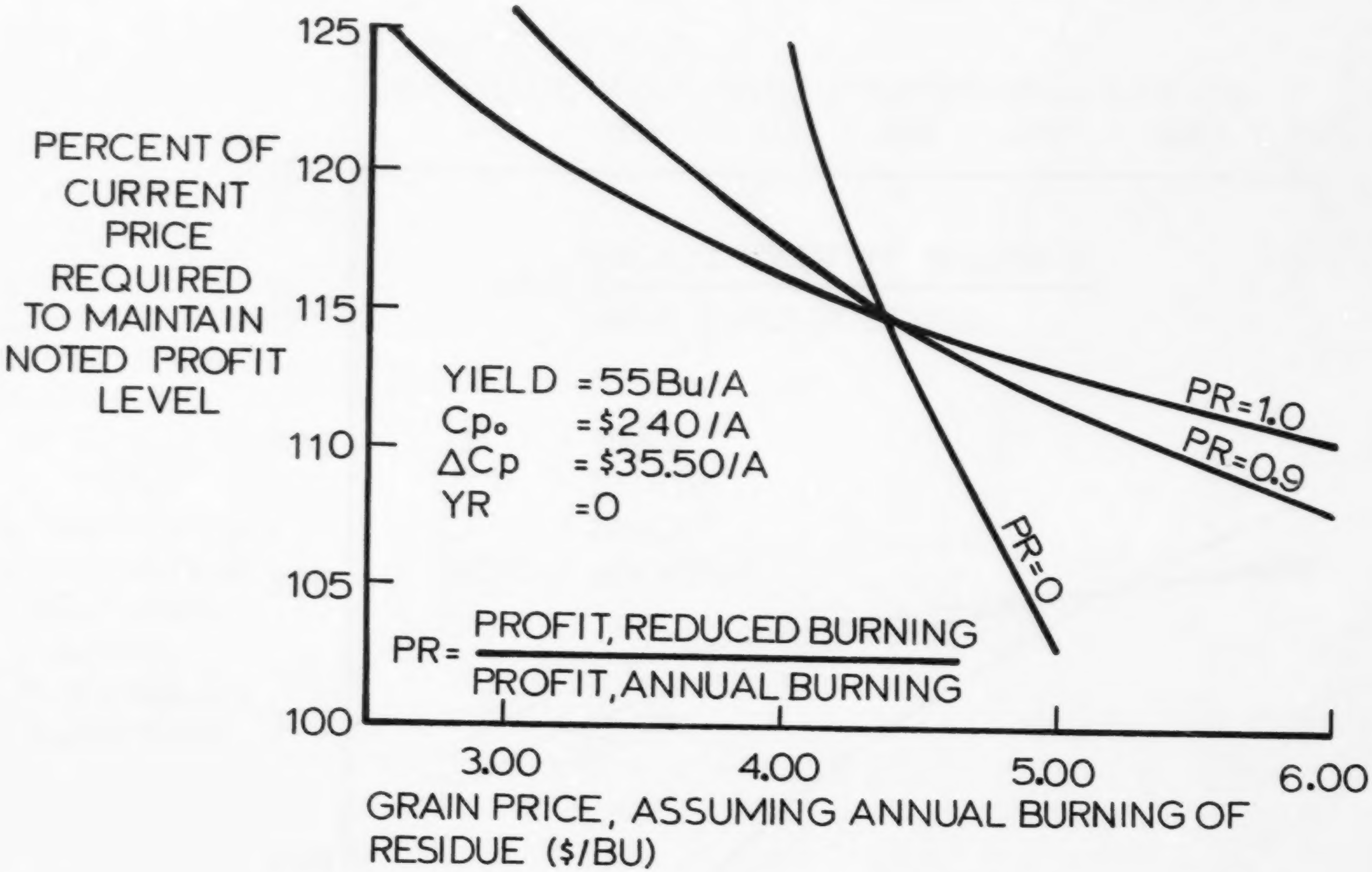

Figure 4-5 Percentage Price Increase Required to Maintain Noted Profit (Net Return) Levels for Cereal Crops.

The loss in yield due to reduced burning would result in increasing seed prices in the short-term as production decreases and seed inventories are depleted. Beyond this initial change, net effect of the reduced burning weario on acreage and production is not clear. The econometric model of Folwell, Burt, and Wirth (1978) predicted increases in acreage in respnse to long-term higher prices for seed. However, the acreage prediction element of this model was based on seed prices and did not take into account net returns to growers. These net returns would be reduced substantially unless prices would increase to levels comparable to those of Figures 4-2 through 4-5. It is not clear whether growers would respond most strongly, in selecting crop alternatives, to market price or net return.

It seems clear that the loss in Idaho production and associated short-term seed price increase would stimulate acreage increases in areas not affected by restrictions on burning. As illustrated in Figure 2-6, seed growers in Idaho and Washington have shown a remarkable responsiveness to such market changes whereas changes in Oregon acreage have been less dramatic. It could be anticipated then that reduced production in Idaho due to burning restrictions would be replaced by additional production in these two areas, principally Washington.

Also, a distinct production cost advantage would accrue to these competitive areas that retained annual burning. Lower production costs in what are otherwise equivalent circumstances would tend to keep seed prices low; perhaps below profitable levels for Idaho producers. Under this scenario, long-term grass seed production would tend to migrate toward these lower production cost areas, provided replacement crops in Idaho were more profitable than Kentucky bluegrass under a reduced burning program.

4.4 Benefit-to-Cost Analysis for Reduced Burning Alternatives

As noted in Section 4-1, the air quality benefits and resulting cost increases to achieve them were the two most important WANT objectives of the previously compiled list. Any program devised for smoke control should attempt to maximize air quality benefits for a given additional financial burden to seed producers and processors and the public. In fact, for the post-harvest alternatives discussed here, perhaps the most significant factor to establishing the worth of proposed changes in practices is the ratio of the resulting emission reduction and the associated cost to the seed producers. Using acreage not burned as an indicator of the net emission reduction and increased production expenses and reduced seed revenues as costs, the selected alternative treatment preferably would maximize the ratio:

$$^{B}/_{C} = \frac{\text{Acreage Not Burned}}{\begin{array}{l}\text{Increased production cost}\\ \text{plus reduced revenues}\end{array}}$$

or

$$^{B}/_{C} = \frac{A_{NB}}{A\ (\Delta\ Cp + YR \cdot P)}$$

or more simply

$$^{B}/_{C} = \frac{\%A_{NB}}{(\Delta\ Cp + YR \cdot P)}$$

where

$^{B}/_{C}$ = Benefit-to-cost ratio

$\%A_{NB}$ = Percent of the total Acreage which will no longer be burned

$\Delta\ Cp$ = The increase in production costs(\$/A

YR = The reduction in yield (lbs./A)

P = Prevailing seed price (\$/lbs.)

It should be understood the Benefit-to-Cost ratio proposed here is for comparison purposes only and should not be confused with B/C ratios used in traditional analysis. Those analyses rely upon a value in dollars being assigned to benefits, a task beyond the scope of this report. Using this traditional approach a B/C ratio greater than 1.0 is desireable. However, B/C ratio values used here have no particular meaning except in comparison to B/C ratios of other alternatives. (Riggs, 1968)

Clearly, the maximum achievable benefit-to-cost is a function of prevailing seed price with the ratio being highest when seed prices are low and vice versa. Thus, as is usually the case, a reduction in emissions can be effected most economically when there is the least amount of capital to pay for the change.

Plotting of the above equation against seed price displays the range of benefit-to-cost (B/C) ratios that are possible under various market conditions. Several examples are plotted in Figure 4-6. The plotted examples were selected to describe the range of the B/C variable under the variety of crops and treatments included in Table 4-II. As may be seen, by far the best B/C ratio is achieved when alternatives to the burning of cereal residues are selected. Compared to this cereal B/C grouping, alternatives to grass seed field burning are grouped

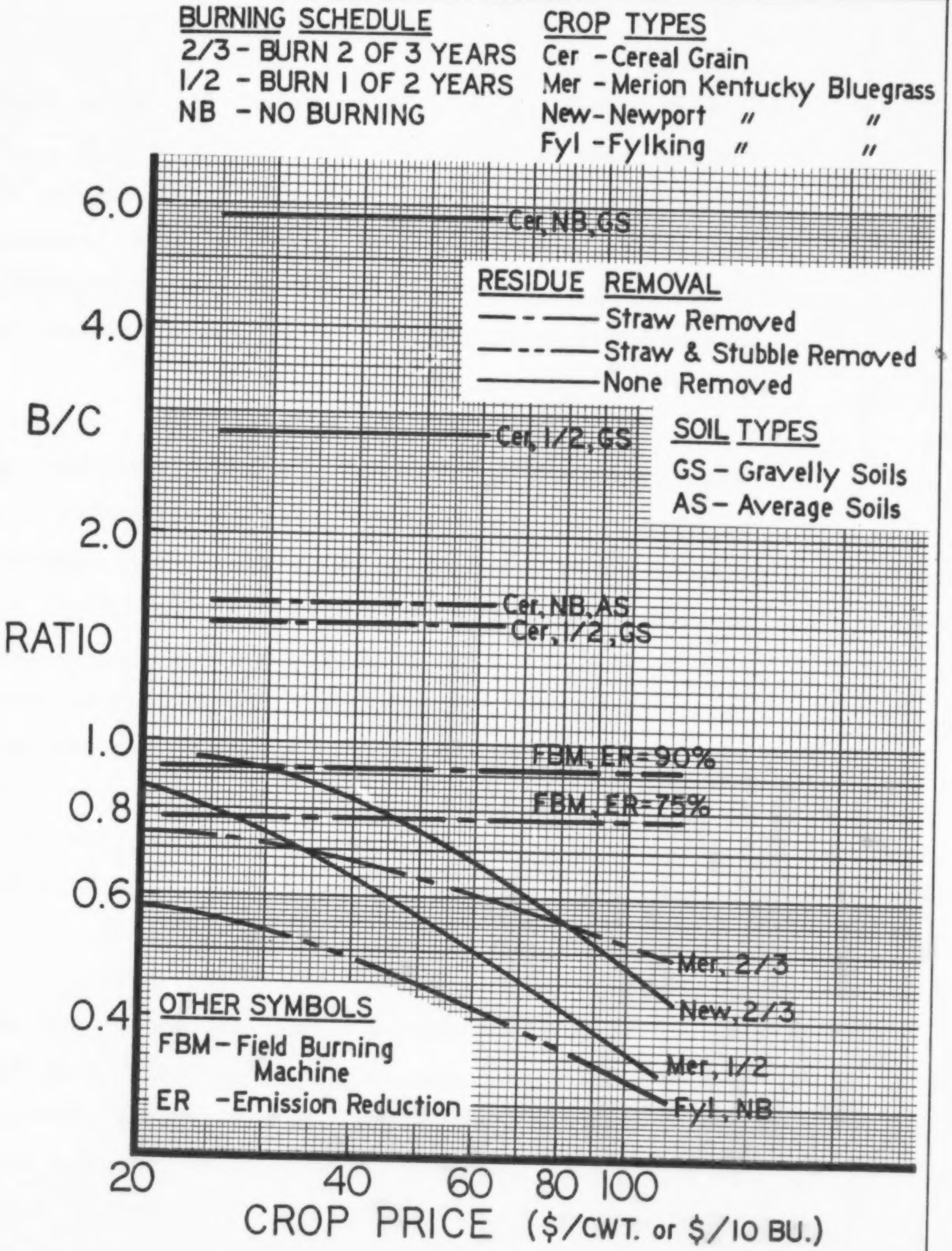

Figure 4-6 Emission Benefit-to-Cost Ratios for Various Alternative Post-Harvest Treatments, Burning Schedules, and Seed Prices for Kentucky Bluegrass and Cereal Crops.

at much lower values. B/C values for grass seed field burning alternatives are roughly one-half to one-tenth those for cereal burning. Based solely on B/C values, reductions in cereal acreage burning should be sought first. Reduction in cereal burning, of course, is indicated also from agronomic and in most areas, soil conservation viewpoints.

Among grass seed varieties, it is very difficult to separate on the basis of cost/benefit a crop/treatment circumstance which is clearly better, especially when the variability of the data is considered. Also, it must be remembered that the great variability in individual farms operations have been condensed into the few cultural, harvest and post-harvest treatment options presented here. Of necessity the number of varieties selected for this analysis had to be small, however, they were selected to cover a wide range of expected circumstances.

Merion Kentucky Bluegrass was included in the analysis because research indicated it to be the variety perhaps least affected by reduced burning. It is also a relatively low-yielding variety that would act as a surrogate for the generally lower yielding proprietary varieties commonly grown under irrigation on the Rathdrum Prairie. Fylking Kentucky Bluegrass was included because it is particularly responsive to the effects of burning, and Newport is a relatively high yielding public variety commonly grown in dryland areas of Kootenai, Benewah, and Latah counties. Of course, the overall selection of varieties for this analysis are limited to those on which post-harvest treatment effects have been studied; and this was a key factor in selecting these varieties, also.

Even with the range in yields and apparent responsiveness to fire presented by these varieties, resulting B/C values for any given seed price all fall within about 25% of th mean B/C value. General inspection of the B/C plots of Figures 4-7, 4-8, and 4-9 show Merion to sustain the highest values and Fylking and Newport to overlap broadly. However, the author believes it is inappropriate to use this observation to support a differentiation of the need to burn based on variety. At present, there is no information on the effects of reduced burning on 80% of the Kentucky bluegrass varieties eligible for certificaton in Idaho. Thus, it is impossible, without doing supporting research, to determine whether a particular variety is Merion-like or

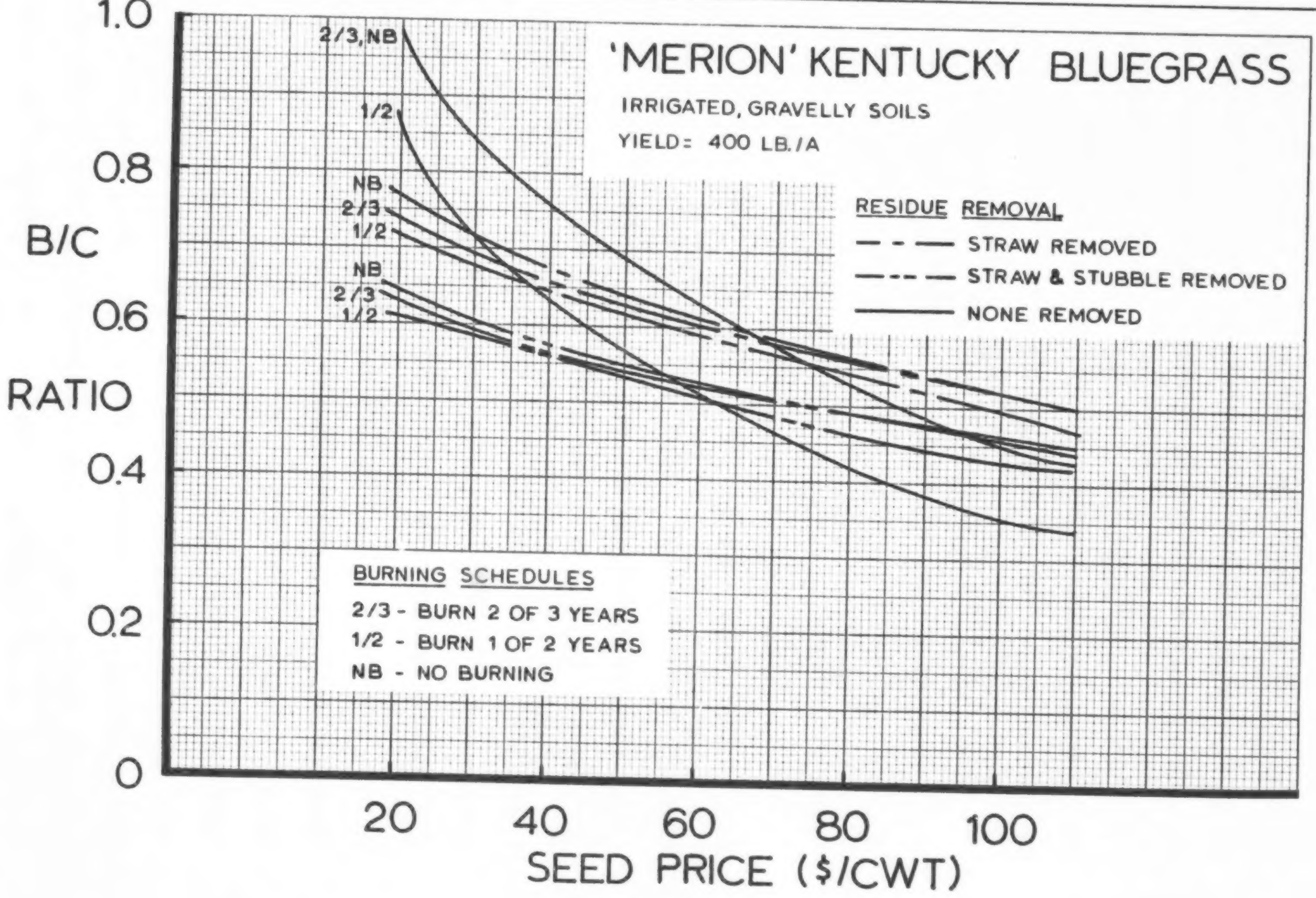

Figure 4-7 Emission Benefit-to-Cost Ratios for Various Alternative Post-Harvest Treatments, Burning Schedules, and Seed Prices for "Merion" Kentucky Bluegrass.

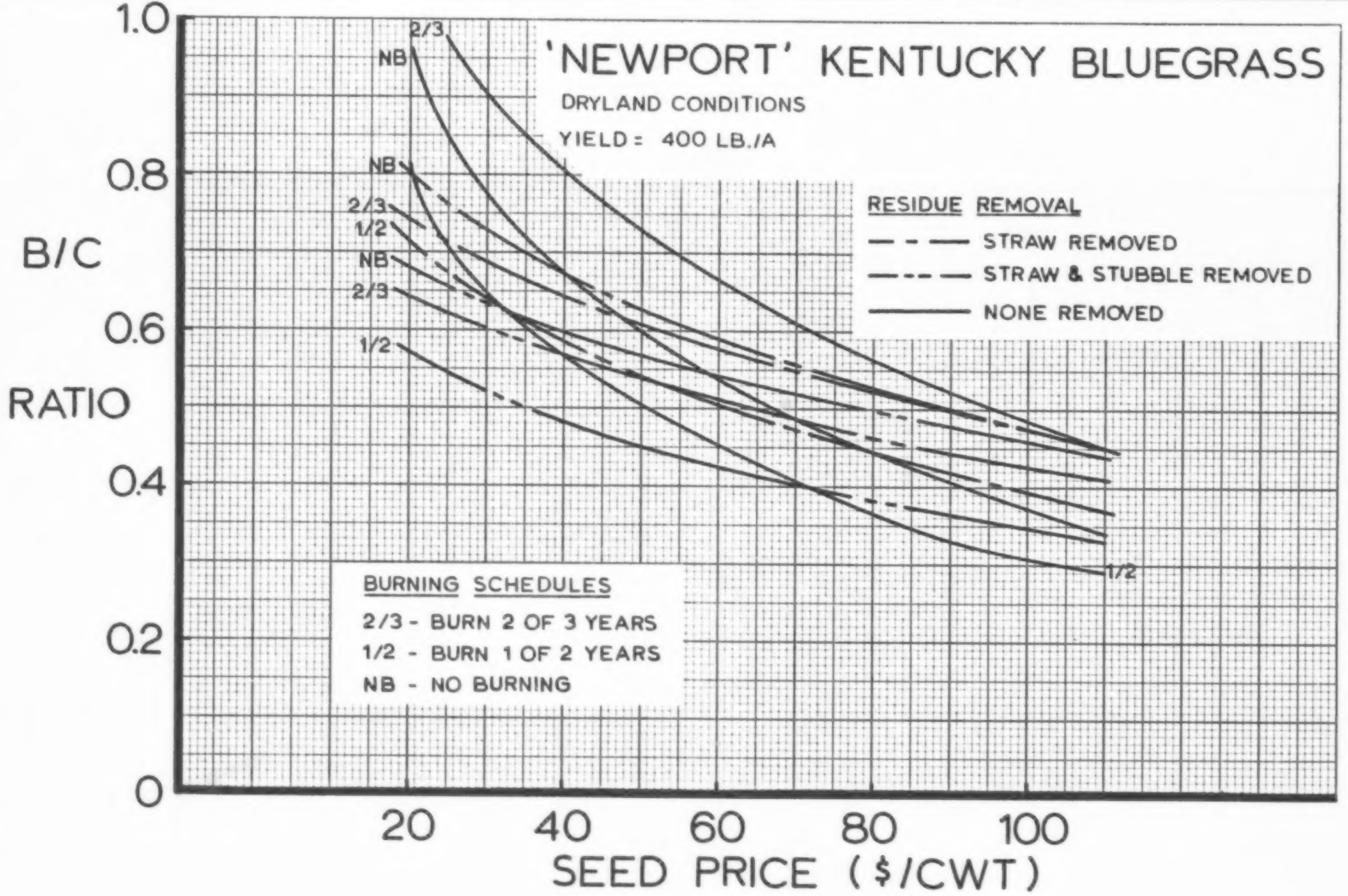

Figure 4-8 Emission Benefit-to-Cost Ratios for Various Alternative Post-Harvest Treatments, Burning Schedules, and Seed Prices for "Newport" Kentucky Bluegrass.

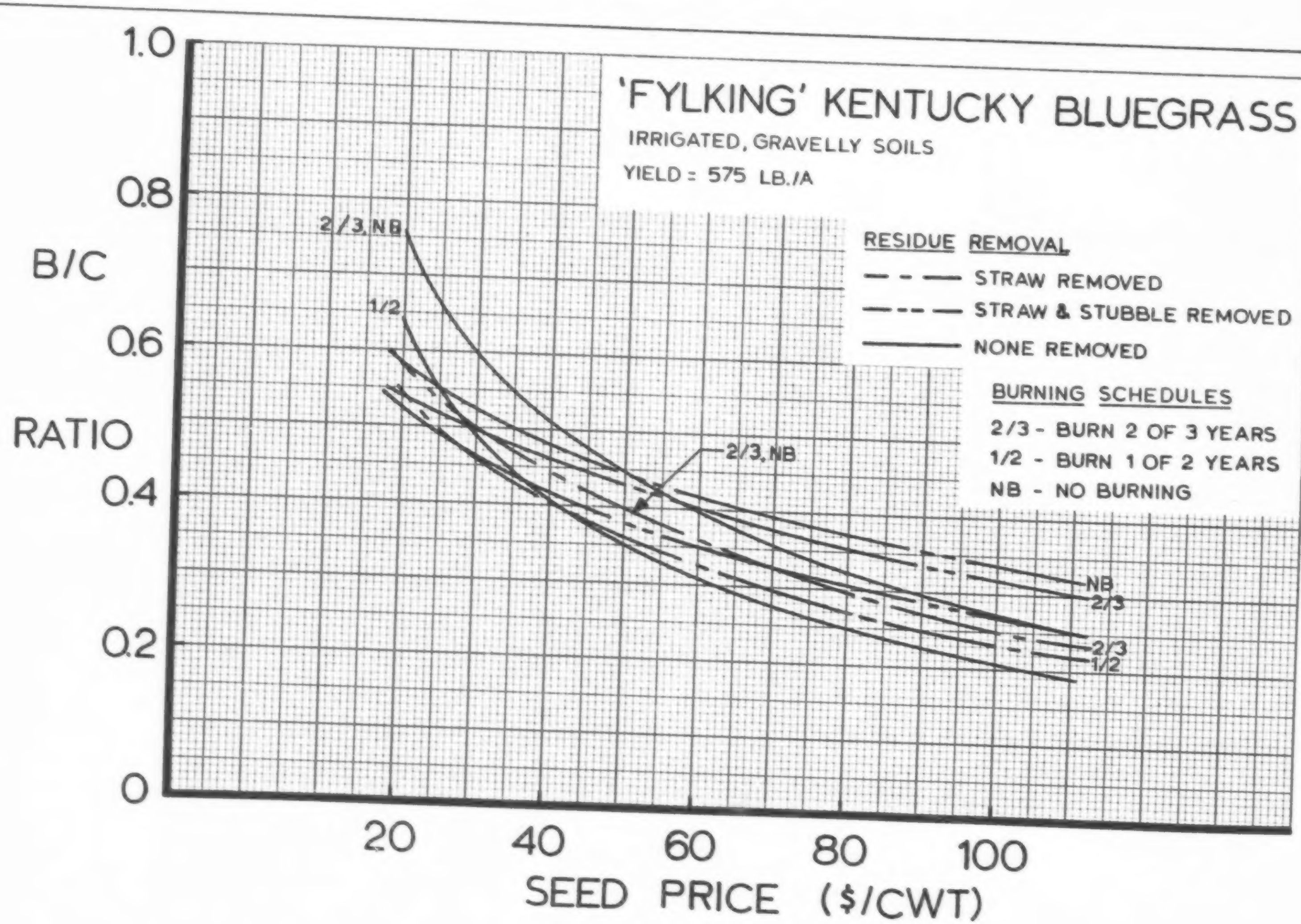

Figure 4-9 Emission Benefit-to-Cost Ratios for Various Alternative Post-Harvest Treatments, Burning Schedules, and Seed Prices for "Fylking" Kentucky Bluegrass.

Fylking-like in its response to reduced burning and, therefore, whether reduced burning is reasonable for that cultivar.

Though there is some difference among varieties based on B/C evaluation, no such differences can be identified among treatments with the exception of machine burning. However, the superiority of the machine is dependent on its net emission reduction capabilities. If the machines can reduce emission by eighty percent compared to open burning, it would maintain a superior B/C ratio compared to other alternatives.

No straw removal alternatives clearly rate high B/C values; however, as noted in research, the value of straw removal is variety-dependent. Thus, straw and stubble removal is effective at reducing net costs for Fylking and consequently the Fylking straw and stubble treatments score higher B/C's under each burning scenario. Similarly, Merion straw removal treatments rate highest for that species. However, no other across-the-board statements on cost effectiveness of treatments can be made based on this data and analysis.

An analysis of the levels of burning was conducted assuming acreage reductions of 33%, 50%, and 100% for the two-out-of-three (2/3), alternate year (1/2), and no burn options. Summary results are contained in the Appendix. Mid-range seed prices were assumed. Regardless of variety or straw removal technique, the highest B/C ratios were for the no burning option, indicting the somewhat slower growth in production costs compared to yield reduction as burning is progressively reduced. However, also in all circumstances, the two-out-of-three year option B/C levels were very close to those of the non-burning option. In one case, for Newport with no straw removal, the 2/3 option obtained the highest B/C value.

In both the total and incremental B/C analysis B/C values for the 2/3 and non-burn options were tightly grouped while those for the 1/2 option were distinctly lower. Thus, on a B/C basis, alternate year burning would not be favored. Of course, the 2/3 option represents the lowest additional cost to grass seed producers of the reduced-burning alternatives analyzed here.

4.5 Rating of Alternative Post-Harvest Treatments

Alternatives to open field burning are all more expensive than continuation of the present practice. However, alternatives involving a reduction in the number of acres burned also would have a lessened impact on air quality. In most instances where air pollution reductions have been sought, regulatory agencies have required sources of air contaminants to pay for such equipment or procedural changes that were necessary to bring about the reductions. Generally, such pollution abatement efforts have been so designed as to assure retention of competition and profitable operation. The methodology and schedule for reducing emissions is normally agreed upon between the source and agency with the exact technological approach selected by the source and approved by the agency.

As noted earlier in this report, efforts to develop a control technology that simulates open burning effects on grass seed crops have been only partially successful. Field burning machines, while apparently capable of satisfying agronomic requirements, have been considered too expensive and unreliable. In the near term, they also must be considered unavailable. Research indicates low emission burning techniques to have net higher air quality impacts at locations downwind and within several miles of the fire. Thus, reductions in the amount of open burning may be one of few available alternatives, if significant emission reductions are desired in addition to smoke management controls.

Reductions in emissions (burning) of 33%, 50%, and 100% were analyzed in this report assuming various post-harvest treatments. Each of these alternatives must be rated as to its potential success in fulfilling program requirements (MUSTS) and other desirable traits (WANTS). Table 4-III displays the ratings of several alternative burning programs based on the MUSTS and WANTS defined in Section 4.1. The higher the numerical rating, the more nearly the proposed program alternative meets the identified objectives.

All of the reduced burning alternatives for grass seed would require substantial increase in crop prices to maintain even reduced net return levels. To keep required seed price increases to a minimum, the reduction of burning would need to be minimized, recognizing the goal of decreased overall emissions. Of the alternatives presented in Table 4-III, the program eliminating cereal burning ranks highest, would eliminate approximately sixteen percent of the grass field burning emissions, and would not significantly effect the grass seed enterprise. Also, these emission reductions would occur almost entirely in the sensitive Rathdrum Prairie area. The increased costs, however, would be near $30 per acre not burned. There would be no yield reduction. The high ranking for this option is traceable to the benefit-to-cost ratios for reduced cereal burning, which are the highest of any alternative post-harvest option.

Reduced burning affects cereal grain growers' operations and prices to a much lesser extent than those of grass seed producers. Since yield would not be noticeably affected, net cost increases are due primarily to increased tilling costs. Benefits of improved erosion control and soil tilth were not costed, though in some circumstances, may be of considerable value. Net fertilizer savings were of a small consistent benefit, while short-term nitrogen augmentation to meet increased residue decomposition requirements was assumed to have no effect on costs over a long-term crop rotation cycle. Because of the much less significant costs and adverse agronomic effects, efforts to reduce total agricultural open

Table 4-III

Ratings of Alternative Post-Harvest Treatment Programs

Alternative Treatment Program	WANT Objectives (See Table 4-I)						
	Exposure to Smoke (11)	Net Costs (10)	Adverse Aesthetic Effect (5)	Changes in Farm Management (4)	Season Length and Uncertainty (1)	Comparable Poll. Control Cost (1)	Weighted Score
1. Prohibit Cereal Burning (Dryland Only)	0	10	0	10	0	8	148
2. Alt. (1) + Prohibit ½ Irr. Cereal	1	10	1	9	1	9	162
3. Prohibit All Cereal	3	10	4	9	3	10	202
4. Alt. (3) + 2/3 Program for Grass Seed	5	6	6	7	3	8	184
5. Alt. (3) + 1/2 Program for Grass Seed	6	5	7	4	3	6	176
6. Prohibit All Burning	10	0	10	0	10	2	172
7. Machine Burn All Acreage*	7	5	8	6	0	3	194
8. Present Open Burning Program*	0	10	0	10	0	7	147

* Do not meet MUST requirements. Included for comparison purposes.

burning emissions should include, as a first priority, the reduction of cereal grain burning.

The program allowing burning in two of three years (2/3) alone would provide an emission reduction roughly equivalent to that of eliminating cereal (Idaho Department of Health and Welfare, 1983), but at a higher cost. This option would increase production costs by $20 to $50 per acre. Yield reductions would be 5-35%, depending upon variety, post-harvest treatment, and length of rotation. Obviously, it would rank lower than the alternative eliminating cereal burning only.

However, alternatives including reduced grass residue burning in addition to the elimination of cereal residue burning were rated because of their greater emission reduction potential.

Since the effect of reduced cereal burning is fixed, it is the benefits and costs of reduction grass residue burning that affect the eventual rating of these combination alternatives.

As noted earlier, benefit-to-cost ratios for 2/3 grass seed options are only slightly lower than for no burn alternatives. These two options have benefit-to-cost ratios clearly superior to a biennial burning program. However, greater reductions in burning place greater stress on farm finances and management. Based on minimizing the on-farm financial burden and maximizing B/C ratios, the 2/3 program is selected as the most desirable emission reducing option for grass seed crops.

4.6 Rating of Fields for Open Burning

4.6.1 Cereal Grain Fields

Reductions in emissions to ameliorate field burning-related air quality effects should be sought first through elimination of all cereal crop residue burning. This finding is based on the deleterious effects of the practice on soils, lack of substantial agronomic value, and relatively small additional cost of not burning. Under this approach, requests for burning of cereal residues should be refused. Under a rating system in which 1.0 means all acreage should be burned and 0.0 means no acreage should be burned, cereal requests would receive a 0.0 rating.

The above recommendation is made recognizing the difficulty in obtaining rapid residue decomposition in the gravelly soils of the Rathdrum Prairie area. In addition, it is understood that the costs of tilling in these soils is substantially higher than in non-gravelly areas. These agronomic and economic considerations argue in favor of cereal burning on the Prairie. A straw removal program, while eliminating decomposition concerns, would add greatly to production costs, assuming no straw market. However, without straw removal, net additional costs to cereal growers on the Rathdrum Prairie would be substantially less than any other program resulting in equivalent emission reductions.

4.6.2 Kentucky Bluegrass Fields

The combined program including the elimination of cereal burning and the 2/3 program for burning Kentucky bluegrass seed residue rates very near the elimination of cereal burning alone in successfully fulfilling the identified rating criteria. The higher costs, principally, result in a somewhat lower overall rating for this approach. It is therefore, not recommended as an initial step in emission reduction through alternative post-harvest treatment. However, it should be considered as a subsequent phase of emission reduction after the elimination of cereal burning and the weighing of any emission reductions brought about through operational smoke management.

Should it be considered appropriate to implement a 2/3 program, it should be remembered that Kentucky bluegrass fields that have been consistantly burned can better withstand the loss of a burning treatment than those that have not been so burned. Younger, more open stands seem to better maintain yields than old, heavily thatched stands. Though straw removal activities will affect subsequent yields, air quality management decisions regarding field burning should not consider this element of the grass seed enterprise since the selection of non-burning residue management options are more properly addressed by the farm manager. Otherwise, a procedure designed to cost-effectively reduce emissions would unnecessarily regulate post-harvest residue management practices.

To promote the 2/3 burning schedule for Kentucky bluegrass fields, a program should assign a high rating (1.0) to a field that had been burned less than two times in the last two years. A lower rating of two-thirds (0.67) would be assigned to fields that had received annual burning for each of the last two post-harvest treatments. Kentucky bluegrass stands having been harvested two times or less also would receive ratings of two-thirds.

4.6.3 Emergency Circumstances

Occasionally, weed, insect, or disease infestations become severe even when best farm management practices are used to avoid them. Under such circumstances, burning may be the only reasonable alternative to control the problem; either to avoid financial disaster or avoid rapid spread to other crops. Such circumstances may warrant consideration of additional burning for individual fields beyond the limitations of a ban on cereal burning or a 2/3 program for grass seed. To allow for such circumstances, any program instituted to reduce burning also should provide for additional burning to be conducted under emergency circumstances. The nature and extent of the problem should be fully described and the special need-to-burn attested to by a recognized agricultural expert.

Applications to burn properly supported by such information would receive a high rating of 1.0.

4.7 Determining Acreage to be Burned

To the greatest extent possible, decisions regarding the needs of specific fields should be made by farm management. Thus, decisions regarding the burning of individual fields should be made by the seed producer within agreed upon overall acreage limitations and smoke management constraints. Such an approach would allow a grass seed producer to burn a cereal field in lieu of equivalent grass seed acreage that had been authorized for burning.

To implement such a program, an overall acreage limitation would be established by multiplying the previously discussed field rating by the acreage of the field to which it applies. The resulting acreage amount (from 0 to 100% of the field size) would be added to similarly derived acreage amounts for all fields submitted under each ownership. The total acreage so calculated is the upper limit on burning for the ownership to be distributed as necessary to meet farm needs. Under a program to eliminate cereal burning, all cereal fields would receive 0.0 ratings and all grass seed fields would receive 1.0 ratings. The total allowed acreage would be equal to the grass seed acreage submitted by the ownership. If a ban on cereal burning were to be combined with a 2/3 program for grass seed fields, the total acreage allowed would be approximately 67% of the grass seed acreage submitted.

This approach to burning restriction would tend to encourage over-registration of fields (registering fields that are not really planned to be burned) in order to increase the amount of acreage authorized for burning. To prevent such registration, an upper limit for each ownership, based on historical burn registration data, would be established. The upper limit would be set initially at a level considered representative, perhaps the average of recent grass seed acreage registrations. Should a 2/3 program for grass seed be implemented in addition to a prohibition on cereal burning, the limit would be set at two-thirds the historical grass acreage.

Figure 4-10 is a flow diagram for determining the acreage to burned under the proposed allocation procedure.

4.8 Identification and Tracking of Field Information

A less-than-annual burning program such as the 2/3 program for grass seed,must include the capability to track the burning history of individual fields. A system to collect the needed information and retain it for future use must be developed. Normally, this would require methods for identifying fields on a continuing basis, allowing year-to-year analysis of treatments and allowed burning. To establish an enforceable procedure, the exact field location and size must be identified. Field data would require annual updating to incorporate changes in crops, field size, burn history, and the results of inspections.

Currently, field registration, year-to-year, tracking, and inspections are conducted in Oregon. Fields are registered in California, Washington, and Idaho. Both the Oregon and California systems are automated, allowing rapid processing and pre-registering of fields. Similar systems likely would need to be developed for any program that

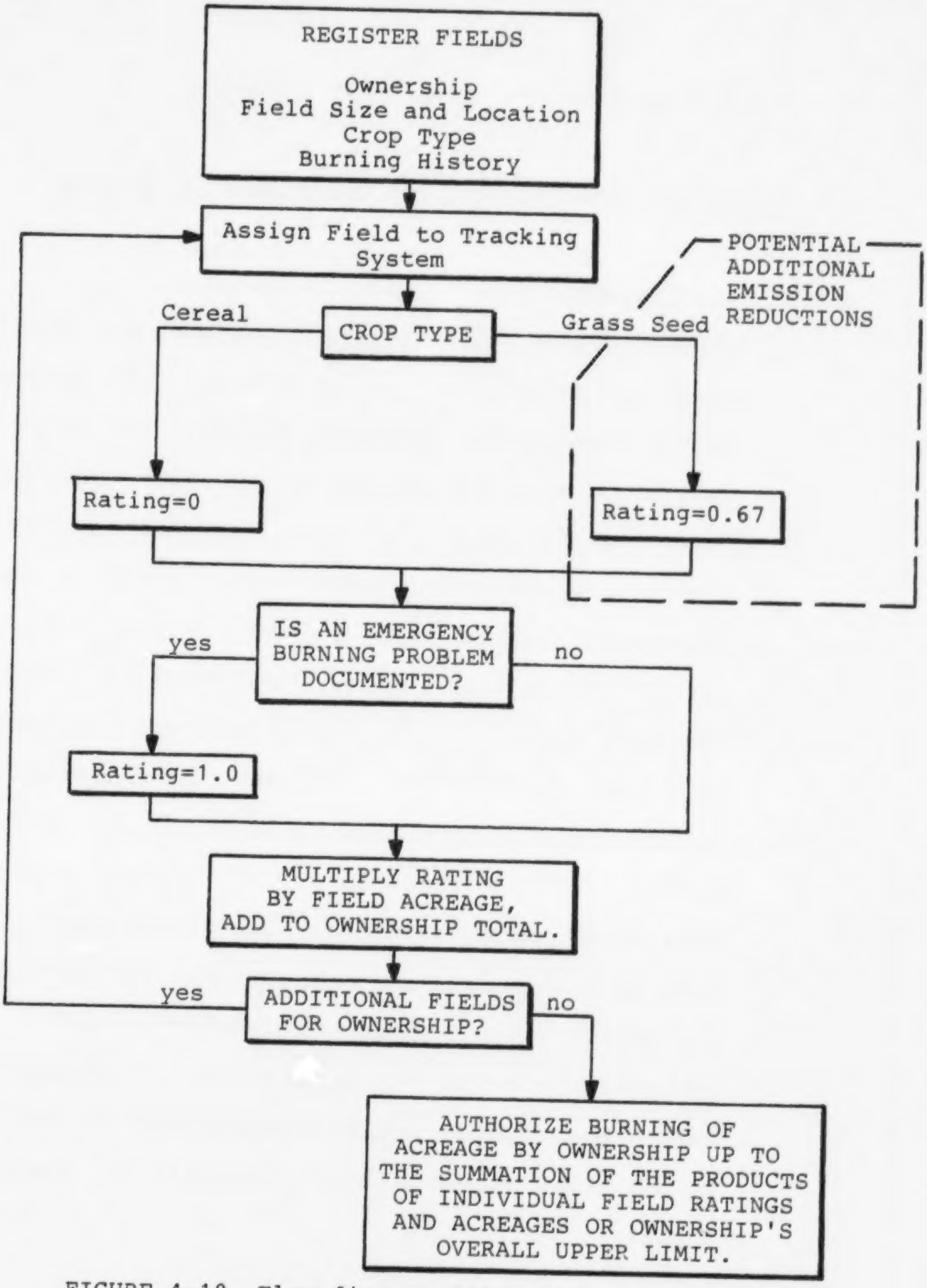
REGISTER FIELDS
Ownership
Field Size and Location
Crop Type
Burning History
Assign Field to Tracking System
POTENTIAL ADDITIONAL EMISSION REDUCTIONS
Cereal
CROP TYPE
Grass Seed
Rating=0
Rating=0.67
yes
IS AN EMERGENCY BURNING PROBLEM DOCUMENTED?
no
Rating=1.0
MULTIPLY RATING BY FIELD ACREAGE, ADD TO OWNERSHIP TOTAL.
yes
ADDITIONAL FIELDS FOR OWNERSHIP?
no
AUTHORIZE BURNING OF ACREAGE BY OWNERSHIP UP TO THE SUMMATION OF THE PRODUCTS OF INDIVIDUAL FIELD RATINGS AND ACREAGES OR OWNERSHIP'S OVERALL UPPER LIMIT.

FIGURE 4-10. Flow diagram illustrating procedure for determining acreage to be authorized for open burning.

tracked acreage over even a few years.

4.9 Effects of Implementing the Reductions in Burning

4.9.1 Air Quality

The integrated effects of smoke on air quality would be reduced in proportion to the seasonal emission reduction, somewhere between 100 and 350 tons of particulate for the elimination of cereal burning depending on the selected emission factor. Because burning would occur under a smoke management program, the reduced burning may not result in smaller daily acreage-burned totals; however, it could if the management philosophy were so directed. Alternatively, management efforts could be bent toward effecting a shorter season. The elimination of the typically late-season cereal would aid most significantly in such an endeavor, but season length is also much influenced by seasonal weather and the availability of appropriate atmospheric conditions. Little could be guaranteed in the way of a shorter season without establishing arbitrary limits.

Air quality improvements may be observable (especially if a shorter season results), but probably would not be measurable due to very limited particulate monitoring in the area and a reasonably effective smoke management program which now limits smoke intrusions to sporadic and short-term events.

4.9.2 Acreage Burned

The acreage burned in northern Idaho would be reduced by approximately 4,000 acres. Implementation of a 2/3 program would reduce burning an additional 7,000 acres per year based on 1982 burning data. Grass seed field burning would be limited to about 14,000 acres in Kootenai and Benewah counties. These reductions, of course, would be affected by changes in overall acreage reflective of market conditions.

4.9.3 Production Cost/Seed Prices/Acreage

As noted in Table 4-II, production costs would be anticipated to increase. Kentucky bluegrass yields would decrease under a 2/3 reduced burning. The effect of these changes are difficult to predict. However, the econometric model of Folwell, et. al. (1978) indicated the short-term result would be increased seed prices as supply was reduced. (Cereal prices would not be affected by changes to these small acreages.) However, this result would be altered, no doubt, if burning was not also restricted in Washington. Folwell did not differentiate between Idaho and Washington production areas or practices. For growers with the option, one would anticipate efforts to relocate grass seed acreages in Washington, while cereal grains and other alternative would be established in Idaho. Certainly, any short- or long-term price increase would stimulate acreage increases in areas where net returns justify it. Since burning restrictions tend to reduce net returns, any acreage increases would likely occur sooner and be larger in areas without such restrictions. Thus it should be anticipated that, should Idaho unilaterally impose a program that reduces grass seed field burning, the state's share of the Kentucky bluegrass seed market would diminish.

Assuming, because of its high benefit-to-cost ratio, cereal crop burning is eliminated first, the cumulative cost to grower of not burning may be estimated using the data of Table 4-II, Figure 4-1, and burn accomplishment records for the 1982 burning season. Such cumulative costs are illustrated in Figure 4-11. Relative to these costs, regulatory expenses are small; however, other public costs (related to health recreation, safety, etc.) may not be comparably small. The determination of these latter costs is an extremely complex problem and is beyond the scope of this study; however, it is clear that such costs would diminish as burning is reduced.

4.9.4 Regulatory Changes

General authority to modify and restrict burning now exists in the Rules and Regulations for the Control of Air Pollution in Idaho. A ban on cereal burning would be relatively easy to implement provided no challenges to the regulatory authority surfaced. Field enforcement of a specific ban on cereal burning would be straightforward in most cases.

Should a 2/3 program be determined appropriate, field enforcement difficulties would increase significantly since acreage totals by ownership would need to checked to determine compliance. Individual fields would need to be inspected and totalled for each ownership selected for review.

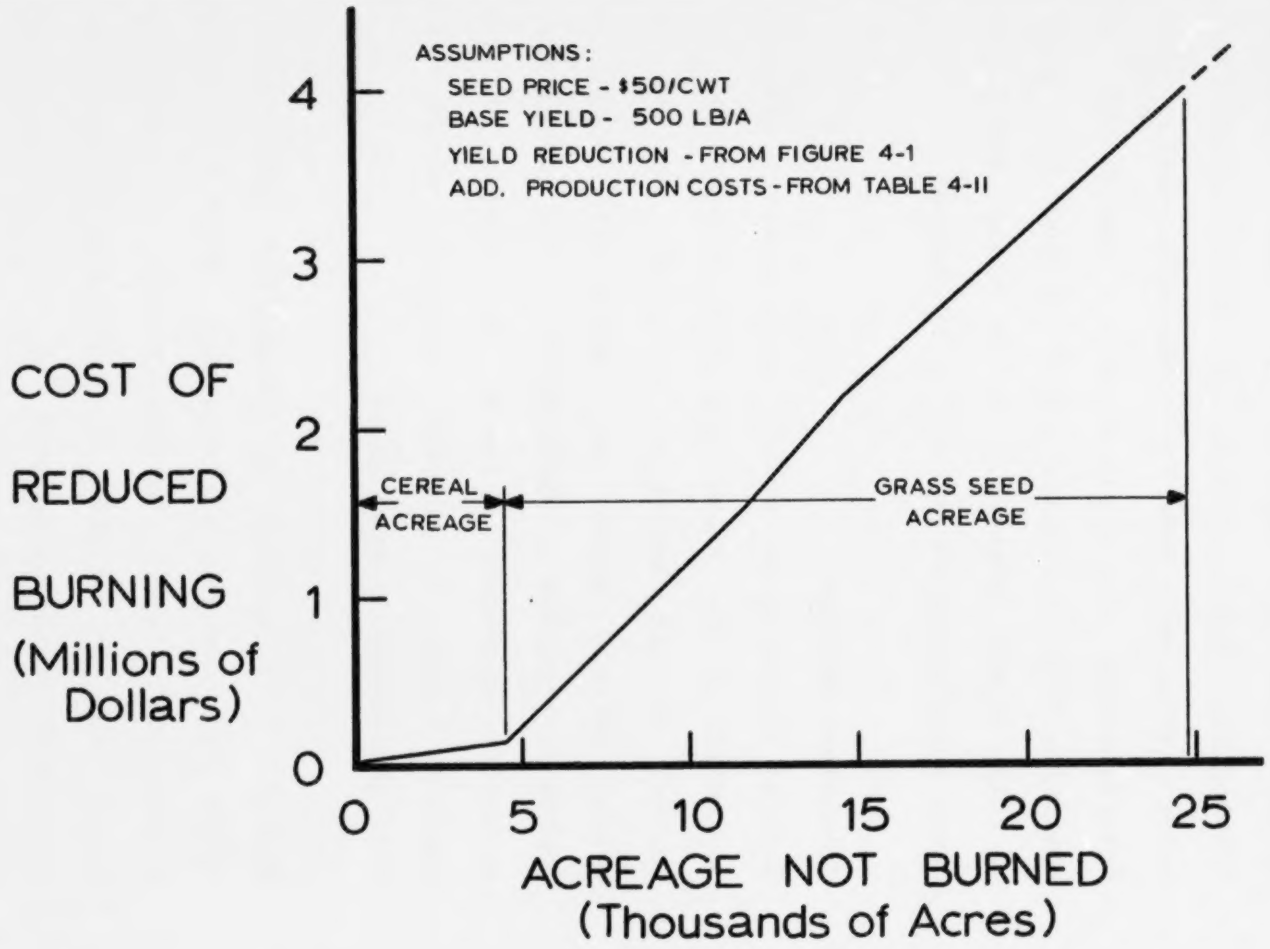

Figure 4-11 Estimated Cummulative Additional Costs Accruing to Idaho Seed Producers Resulting from Reduced Open Burning.

Also, emergency burning requests would require review and, possibly, investigation to determine appropriate additional burning.

Regardless of the authority implied in the existing general language of the Idaho rules, the author strongly recommends, in light of the potential impacts of the changes in post-harvest treatments discussed in this report, that clear and specific regulatory language be adopted regarding burning restrictions, methods for allocating burning, and methods for treating exceptions. Regulatory limits on operational smoke management activities also should be clearly defined and constructed to integrate with and take advantage of other limitations on burning.

SECTION 5

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REFERENCES

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SECTION 6

APPENDIX

DERIVATION OF ASSUMED YIELD REDUCTIONS OF TABLE 4-II

Yield data from applicable research, primarily Canode and Law (1977) and Chilcote, et. al. (1975, 1981, 1982), is summarized in Table A-I. From these data average yields (as percentages of annual open burn yields) were calculated for periods of 4, 5, and 6 seed crops. Missing data points were calculated based upon a linear regression using available data, however, a minimum yield of 25% was used when a linear regression would predict a lower value. The methodology for missing data calculation is illustrated in Figure A-I.

Data used in determination of yield averages is shown for each variety in Tables A-II through A-VI.

TABLE A-1
SUMMARY OF YIELD DATA FOR FIVE VARIETIES OF KENTUCKY BLUEGRASS SUBJECTED TO REDUCED-BURNING POST-HARVEST TREATMENT
(EXPRESSED AS PERCENTAGE OF COMPARABLE ANNUAL OPEN BURN YIELD)

Seed Crop No.		VARIETY				
		Newport	Fylking	Merion	Cougar	Garfield
1		100	100	100	100	100
2	SR	80,64	66,29,28	100,68,82	75,64	75
	SSR	77,64	68,53,57	93,72,71,100	78,58	85
	AY	88	70	101	80	
	NONE		20			60,
3	SR	55	37	77,55,76	32	46
	SSR	53	54	59,92	23	
	AY					
	NONE					12,
4	SR	67	30	64,97	52	38
	SSR	89	74	102,126	48	
	AY	75	68	82	76	
	NONE					24
5	SR		34			
	SSR		60			
	AY					
6	SR		0			
	SSR		0			

Table A-1 (Continued)

Other Average Yield Data (No. of Seed Crops)

	Newport	Fylking	Merion	Cougar	Garfield
SR			73(4)		
SSR			75(4), 69(3)		
AY			95(3)		
NONE	108(2)		62(4), 76(2)		47(4)

POST-HARVEST RESIDUE TREATMENTS:

SR-Straw Removed
SSR-Straw and Stubble Removed
AY-Alternate Year Burn With SR
NONE-No Residue Removal

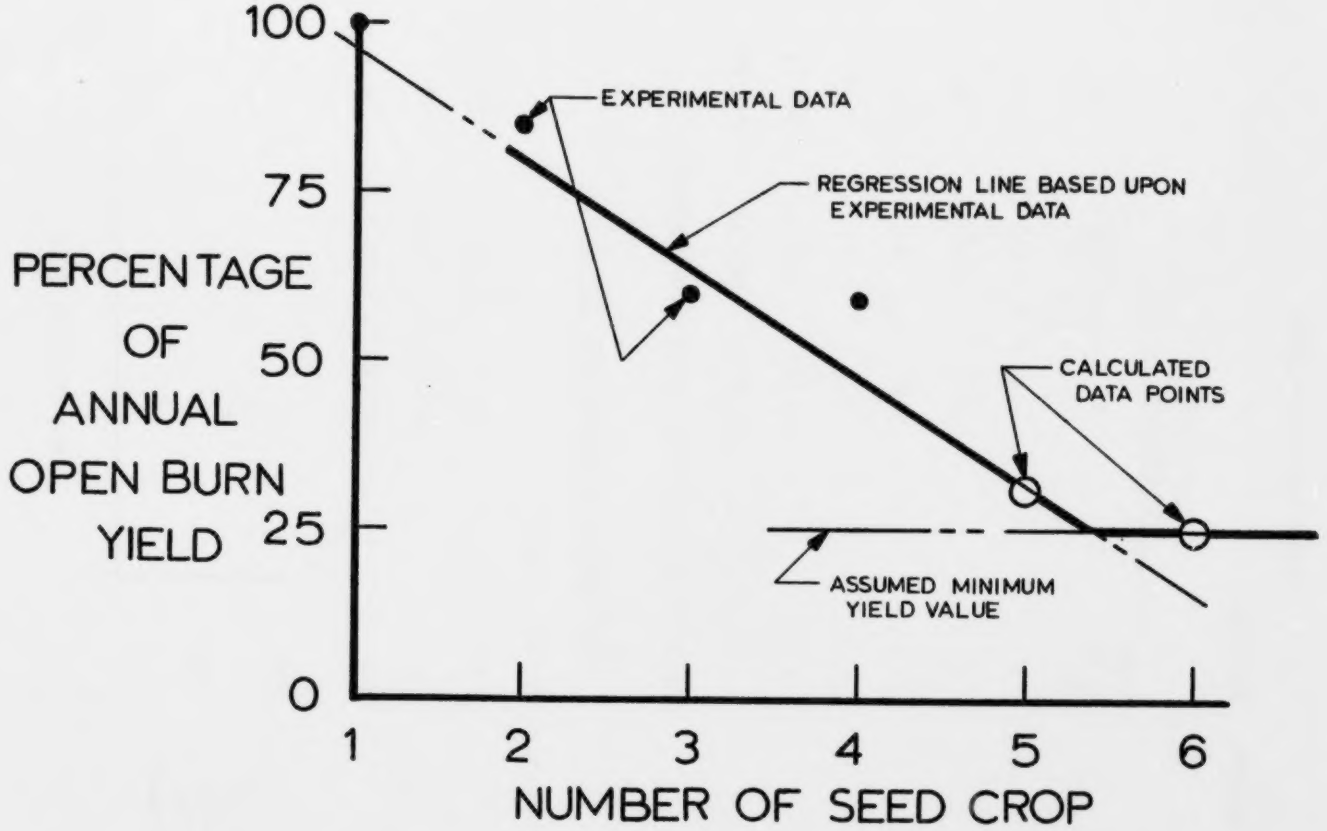


Figure A-1 Methodology for Determining Missing Seed Yield Data Used in the Calculation of Average Yields.

TABLE A-II

YIELD REDUCTION DATA

VARIETY: NEWPORT

Seed Crop No.	POST-HARVEST TREATMENTS SR (1)	SSR (2)	AY (3)
1	100	100	100
2	72	70.5	88
3	55	53	(82.29)
4	67	89	75
5	(44.5)	(65.5)	(66.14)
6	(32.90)	(60.45)	(58.07)

Parentheses indicate calculated values.

CALCULATED AVERAGE SEED YIELDS

Averaging Period (years)	SR (1)	SSR (2)	AY (3)
4	73.5	78.1	86.0
5	67.7	75.6	82.3
6	61.9	73.1	78.3

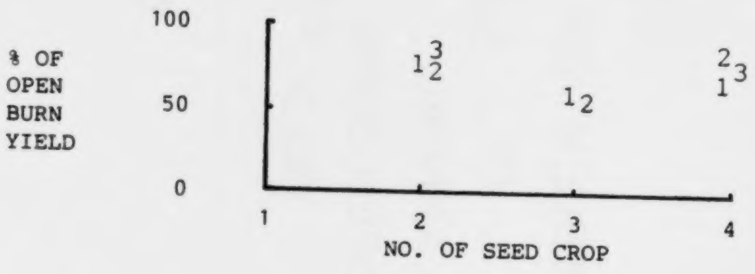


TABLE A-III

YIELD REDUCTION DATA

VARIETY: FYLKING

Seed Crop No.	POST-HARVEST TREATMENTS SR (1)	SSR (2)	AY (3)
1	100	100	100
2	41	60	70
3	37	54	(73.1)
4	30	74	68
5	34	60	(54.57)
6	(5.50)25	(49.80)	(45.3)

Parentheses indicate calculated values.

CALCULATED AVERAGE SEED YIELDS

Averaging Period (years)			
4	52	72	76.7
5	48.4	69.6	73.1
6	44.5	66.3	68.5

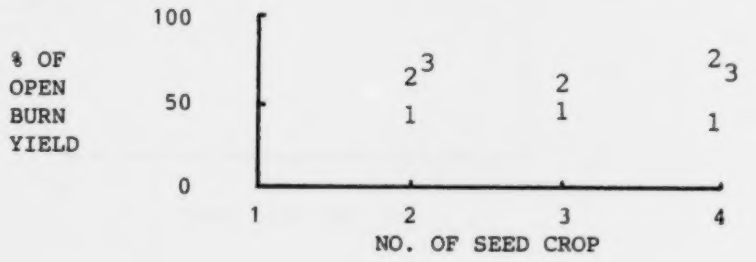


TABLE A-IV

YIELD REDUCTION DATA

VARIETY: MERION

Seed Crop No.	POST-HARVEST TREATMENTS SR (1)	SSR (2)	AY (3)
1	100	100	100
2	83	84	101
3	69	75.5	(90.00)
4	80.5	114	82
5	(65.00)	(101.75)	(77.00)
6	(57.75)	(105.10)	(70.50)

Parentheses indicate calculated values.

CALCULATED AVERAGE SEED YIELDS

Averaging Period (years)			
4	83.1	93.5	93.5
5	79.5	94.9	90.0
6	75.8	96.6	86.6

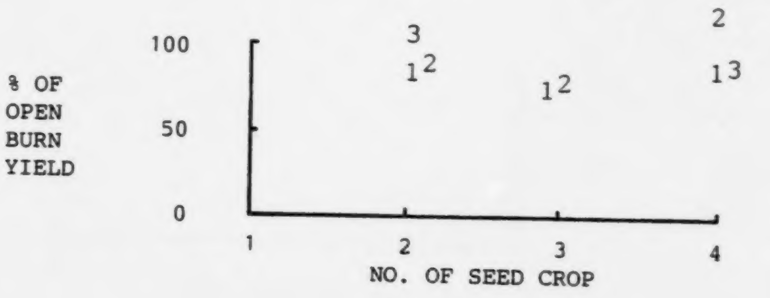


TABLE A-V

YIELD REDUCTION DATA

VARIETY: COUGAR

Seed Crop No.	POST-HARVEST TREATMENTS SR (1)	SSR (2)	ALT (3)
1	100	100	100
2	70	68	80
3	32	23	(80.57)
4	52	48	76
5	(18.00)25	(9.5)25	(66.29)
6	(-0.2)25	(-10.60)25	(59.14)

Parentheses indicate calculated values.

CALCULATED AVERAGE SEED YIELDS

Average Period (years)			
4	63.5	59.7	84.1
5	55.8	52.8	80.5
6	50.6	48	76.9

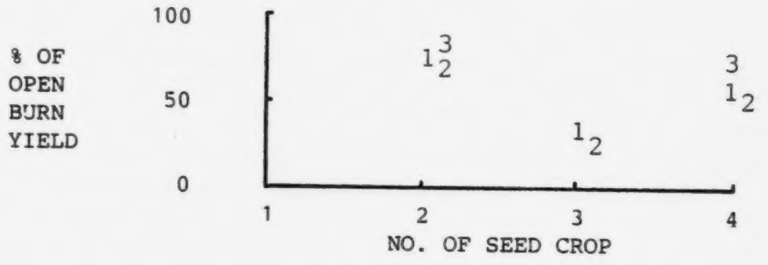


TABLE A-VI

YIELD REDUCTION DATA

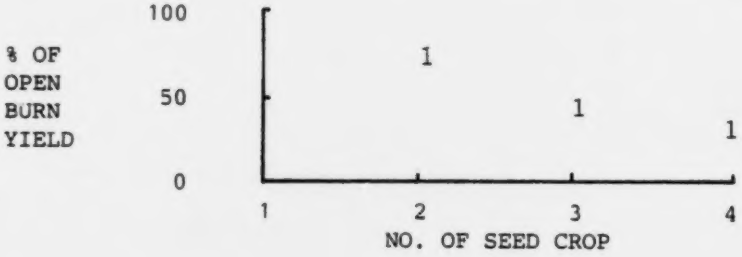
VARIETY: GARFIELD

Seed Crop No.	POST-HARVEST TREATMENTS SR	SSR	ALT
1	100		
2	75		
3	46		
4	38		
5	(11)25		
6	(-10.50)25		

Parentheses indicate calculated values.

CALCULATED AVERAGE SEED YIELDS

Average Period (years)	
4	64.7
5	56.80
6	51.50



DERIVATION OF ADDITIONAL PLOWING COST OF TABLE 4-II

Assumptions regarding the type and number of plowing operations are based upon Idaho crop budgets (Powell, 1983 and Powell, et. al., 1980) and conversation with agricultural representatives familiar with the gravelly soil conditions of the Rathdrum Prairie. The assumptions used are shown in Table A-VIII.

Exceptional repair costs, as encountered in gravelly soils, were utilized to adjust crop budget plowing cost upwards for such area as the Rathdrum Prairie. The extraordinary repair costs were based on actual repair expenses for moldboard plows (Roberts, 1983) and assumed 50% additional repair costs for all other tilling operations.

Additional plowing costs were based on the difference between annual burning and reduced burning tillage costs.

Table A-VII

Data Used to Determine Additional Plowing Costs

Operation		Implement Rates ($/hr.)	Assoc. Power Unit	Power Unit Rate ($/hr.)	HR/A	Cost ($/A)	Gravelly Soil Cost Factor	Gravelly Soil Cost $/A
Mold Board Plow	Dry	9.29	CRT68	18.27		8.54		15.49
(5B)	Irr.	9.29	CRT68	18.31	0.31	8.55	6.95	15.50
Offset Disk	Dry	50.76	CRT125	36.07		5.21		5.51
	Irr.	39.18	CRT90	33.00	0.06	4.33	.30	4.63
Cultivator	Dry	13.81	CRT68	18.27		1.92		2.07
	Irr.	14.71	CRT68	18.31	0.06	1.98	.15	2.13
Harrow	Dry	10.23	T125	49.49		1.79		1.82
	Irr.	7.33	T125	55.32	0.03	1.87	.03	1.90
Packer	Dry	11.83	T30	10.51		1.34		1.39
	Irr.	15.93	T30	23.78	0.06	2.38	.05	2.43
Total Costs	Dry							
	Irr.							

Notes:

KBg costs are for establishment year only
[ ] indicate gravelly soil costs.

Table 4-VII cont.

Number of Times Across Field

Operation		KBg w/burn	KBg w/o burn No SR	KBg w/o burn SR	Wheat w/burn	Wheat w/o burn No SR	Wheat w/o burn SR
Mold Board Plow 5B	Dry					0	
	Irr.	1	1	1		1	
Offset Disk	Dry					1	1
	Irr.	1	3	2	1	2	2
Cultivator	Dry						
	Irr.	2	2	2	1	2	1
Harrows	Dry						
	Irr.	2	2	2	1	1	1
Packer	Dry						
	Irr.	1	1	1			
Total Costs	Dry	22.51	32.93	27.72	7.87	10.19	7.87
	Irr.	22.96	31.62	27.29	7.87	24.57	11.63
Notes:	Dry	[30.17]	[41.19]	[35.68]	[8.35]	[10.82]	[8.35]
	Irr.	[30.62]	[39.88]	[35.25]	[8.35]	[32.45]	[12.41]

KBg costs are for establishment year only
[ ] indicate gravelly soil costs.

PAIRED COMPARISON ANALYSIS FOR THE RATING OF "WANT" OBJECTIVES

LISTED WANT OBJECTIVES

A. Minimize net exposure to smoke
B. Minimize season length and burning uncertianty
C. Minimize adverse aesthetic effects
D. Minimize changes in farm management needs
E. Minimize reductions in net return
F. Make pollution control cost comparable to those of similar industries

A						
B	A3					
C	A2	C2				
D	A2	B1	D1			
E	A1	E3	E2	E2		
F	A3	F1	C3	D3	E3	
	A	B	C	D	E	F

TOTALS:

11	1	5	4	10	1

LETTER - Indicate preferrable objective
NUMBERS - 1-little difference; 2-some difference; 3-significant difference.

EXAMPLE CALCULATIONS OF AUTHORIZED ACREAGE
(Assuming cereal burning is prohibited and a 2/3 burn program is in effect for Kentucky Bluegrass)

Registration Information

Specific Field Identifier	Crop Type	Location (T, R, S)	Acreage	For grass seed, list the no. of times this stand has been burned in the last two years
1021 - 01	G	51N,4W,18	42	2
1021 - 02	G	51N,4W,18	28	2
1021 - 03	G	51N,4W,19	120	2
1034 - 01	C	51N,4W,19	40	
1034 - 02	G	51N,5W,32	100	1
1099 - 01	C	47N,5W,9	240	
1099 - 02	C	47N,5W,9	80	

Historical Information

	Last Year	Two yrs. Ago	3 yrs. Ago	Average
Registration for grass seed residue burning for this ownership:	320	--	350	335

Authorized Acreage

Based on present application	Based on historical data	Based on 2/3 historical data
0.67 X (42 + 28 + 120) + 0.0 X (40) + 1.0 X (100) + 0 X (320) = 248	335	223

Supplement to Table 4-II

COST DETERMINATIONS
FOR EQUIPMENT OPERATIONS

OPERATION: Machine burning of post-harvest residue (does not include straw removal costs)

MACHINE COSTS

Field Burning Machine

Cost (new): $65,000
Salvage : 6,000
Life : 7 years @ 200/hrs./yr.
Operating Rate: 3A/hr.

	Annual Cost	Hourly Cost	Per Acre Cost
Depreciation	$8,428	$42.14	$14.05
Interest @ 14%	5,325	26.62	8.88
Ins. and Tax	500	2.50	0.83
Fuels (75hpg)		4.50	1.50
Repair	2,000	10.00	3.33
Lube	50	.25	.08
Subtotal	$16,303	86.01	28.67
Tractor (3 yrs. old, 30hpg)			
Subtotal		$10.00	3.33
Pull Tank & Pump (for machine fire control)			
All fixed cost		$ 3.00	1.00
Repair, lube		.50	0.17
Subtotal		$ 3.50	1.17
Auxillary fire control			
Pickup (3/4 T, 4WD, 5 yrs. old)			
Subtotal		$10.00	3.33

Supplement to Table 4-II cont.

COST DETERMINATIONS
FOR EQUIPMENT OPERATIONS

	Annual Cost	Hourly Cost	Per Acre Cost
Pack Tank & Pump			
All fixed costs		$ 2.00	$ 0.67
Fuel, repair and lube		2.00	0.67
Subtotal		$ 4.00	1.34
Labor			
1 @ $6.50/hr. incl. ohd		6.50	2.17
1 @ 5.00/hr. incl. ohd		5.00	1.67
Subtotal		$11.50	$ 3.84
TOTAL		$125.01	$41.68

Supplement to Table 4-II

COST DETERMINATION FOR EQUIPMENT OPERATIONS

OPERATION: Stubble removal by crew-cutting (does not include straw removal costs)

MACHINE COSTS

Crew-Cutter

Cost (new): $18,000
Salvage : 3,000
Life : 10 years @ 200 hrs./yr.
Operating Rate: 2A/hr.

	Annual Cost	Hourly Cost	Per Acre Cost
Depreciation	$1,500	$ 7.50	$ 3.75
Interest @ 14%	1,470	7.35	3.68
Ins. and Tax	210	1.05	0.53
Fuel	0	0	0
Repair	500	2.50	1.25
Lube	25	.13	.07
Subtotal	$3,705	$18.53	$ 9.28
Tractor (3 yrs. old, 100 hpd)		21.64	10.82
Subtotal		21.64	10.82
Labor			
1 @ $6.50/hr. incl. ohd		6.50	3.25
Subtotal		6.50	3.25
TOTAL		$46.67	$23.33

Supplement to Table 4-II

AMORTIZED ESTABLISHMENT COSTS
(Based on Powell, 1983)

IRRIGATED KENTUCKY BLUEGRASS

1983	Variable Costs		$ 96.44
1983	Fixed Costs	146.66	
1983	FC adjusted to reflect 1980 FC's (0.7277 X 1983 FC on all mach. & overhead, no change in land value)(.7277 X 96.66) + 50. =		120.33
			$216.77

NON-IRRIGATED KENTUCKY BLUEGRASS

1983	Variable Cost		$ 62.91
1983	Fixed Cost	95.52	
1983	FC adjusted to reflect 1980 FC's (as above) (.7277 X 45.52) + 50.00		83.12
			$146.03

	AMORTIZED COSTS FOR i = 15%			
AMOUNT	7 yr.	6 yr.	5 yr.	4 yr.
216.77	52.10	57.28	64.67	75.93
146.03	35.10	38.59	43.56	51.15

Supplement to Table 4-II

WEED CONTROL COSTS (Powell, 1983; Claridge, 1983)

IRRIGATED AREAS

	$/HR	X HR/ACRE	= $/A
MACHINERY			
Tractor 30G	23.78	0.09	2.14
Sprayer	7.13	0.09	0.64
MATERIALS			
Chemical	2.4-D (Broad leaf cont.)		= 2.00
	Roundup (Rogue)		1.50
LABOR	6.50	0.09	0.58
	4.50	2.25	10.12
			$16.98

NON-IRRIGATED AREAS

	$/HR	X HR/ACRE	= $/A
MACHINERY			
Tractor 30G	10.51	0.09	0.94
Sprayer	8.77	0.09	0.79
MATERIALS			
Chemical			3.50
LABOR	4.50	2.25	10.12
	6.50	0.09	0.58
			$15.93

DETERMINATION OF RELATIVE PRICE INCREASES REQUIRED WITH TO MAINTAIN IDENTIFIED PROFIT LEVELS REDUCED OPEN BURNING

Profit levels at any time are assumed to be equal to the difference between revenues and production costs. Profits with annual burning and with reduced burning are equated as follows:

$$(YoPo-Cpo)\ PR= (Y_1P_1-Cp_1) \qquad \text{where,}$$

Yo = Yield of seed with annual burning
Po = Price of seed with annual burning
Cpo = Production costs with annual burning
Y_1 = Yield of seed with reduced burning
P_1 = Price of seed with reduced burning
Cp_1 = Production costs with reduced burning
PR = Profit Ratio

The following variables and relationships are also introduced:

$$CP_1 = Cpo + Cp$$
$$Y_1 = Yo\ (1-YR) \qquad \text{where,}$$
$$P_1 = Po + P$$

YR = Yield reduction due to reduced burning
P = Change in price associated with a reduced burning program
Cp = Change in production costs associated with a reduced burning program

DETERMINATION OF RELATIVE PRICE INCREASES REQUIRED WITH TO MAINTAIN IDENTIFIED PROFIT LEVELS REDUCED OPEN BURNING

(cont.)

Rearrangement of the original equation gives:

$$PR\ Yo\ Po - PR\ Cpo = Y_1\ (Po + P) - Cp_1$$

or

$$P = \frac{PR\ Yo\ Po - Y_1\ Po - PR\ Cpo + Cp_1}{Y_1}$$

and

$$P = \frac{Po\ Yo\ [PR - (1-YR)] + Cpo\ (1-PR) + Cp}{Yo\ (1-Yr)}$$

Percentage price increases are thus given by:

$$\frac{100\ P}{Po} = \frac{[PR - (1-YR)]}{(1-YR)} + \frac{Cpo\ (1-PR) + Cp}{Po\ Yo(1-YR)} \quad 100$$

INCREMENTAL BENEFIT/COST ANALYSIS FOR ALTERNATIVE REDUCED-BURNING POST-HARVEST TREATMENTS

"MERION" KENTUCKY BLUEGRASS
Price = $60/cwt
Open Burn Yield = 400 lb./A

Post-harvest residue treatment-Straw Removal

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	59.5	0.0055	
	0.17	32.7		0.0052
1/2	0.5	92.2	0.0054	
	0.5	83.05		0.0058
No Burn	1.0	175.25	0.0057	

Post harvest residue treatment-Straw and Stubble Removed

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	67.5	0.0049	
	0.17	36.7		0.0046
1/2	0.5	104.2	0.0048	
	0.5	95		0.00508
No burn	1.0	199.2	0.0050	

Post harvest treatment-No straw removed

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	64	0.0052	
	0.17	52		0.0032
1/2	0.5	116	0.0043	
	0.5	71		0.0054
No burn	1.0	187	0.0053	

INCREMENTAL BENEFIT/COST
ANALYSIS FOR ALTERNTIVE REDUCED-BURNING
POST-HARVEST TREATMENTS

"NEWPORT" KENTUCKY BLUEGRASS

Price= $50/cwt
Open Burn Yield= 650 lb/A

Post-harvest residue treatment- Straw Removed

Burning Program	Benefit (Burned acreage reduction)		Additional Cost ($/A)		Total B/C	Incremental B/C
2/3	0.33		66.5		0.0050	
		0.17		53		0.0032
1/2	0.5		119.5		0.0042	
		0.5		80		0.0050
No burn	1.0		200.0		0.0050	

Post-harvest treatment- Straw and Stubble Removed

Burning Program	Benefit (Burned acreage reduction)		Additional Cost ($/A)		Total B/C	Incremental B/C
2/3	0.33		74.5		0.0044	
		0.17		57		0.0030
1/2	0.5		131.5		0.0038	
		0.5		77		0.0050
No burn	1.0		208.0		0.0048	

INCREMENTAL BENEFIT/COST ANALYSIS FOR ALTERNATIVE REDUCED-BURNING POST-HARVEST TREATMENTS
(cont.)

Post-harvest residue treatment- No removal

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	66.0	0.0050	
	0.17	71.		0.0024
1/2	0.5	137.0	0.0036	
	0.5	102.		0.0049
No burn	1.0	239.0	0.0042	

INCREMENTAL BENEFIT/COST
ANALYSIS FOR ALTERNATIVE REDUCED-BURNING
POST-HARVEST TREATMENTS

"FYLKING" KENTUCKY BLUEGRASS

Price= $60/cwt
Open burn yield= 500 lb./A

Post-harvest residue treatment- Straw Removal

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	86.5	0.0038	
	0.17	57.		0.0030
1/2	0.5	143.	0.0034	
	0.5	116		0.0039
No burn	1.0	259.	0.0039	

Post-harvest residue treatment- Straw and stubble removed

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	79.	0.0041	
	0.17	55.		0.0031
1/2	0.5	134.	0.0037	
	0.5	89.		0.0047
No burn	1.0	223.	0.0045	

INCREMENTAL BENEFIT/COST ANALYSIS FOR ALTERNATIVE REDUCED-BURNING POST-HARVEST TREATMENTS (cont.)

Post-harvest residue treatment- No removal

Burning Program	Benefit (Burned acreage reduction)	Additional Cost ($/A)	Total B/C	Incremental B/C
2/3	0.33	79.	0.0041	
	0.17	70.		0.0024
1/2	0.5	149.	0.0033	
	0.5	80		0.0045
No burn	1.0	229.	0.0043	